Liquidity Coinsurance and Bank Capital*

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

October 2011

Abstract

Banks can deal with their liquidity risk by holding liquid assets (self-insurance), by participating in the interbank market (coinsurance), or by using flexible financing instruments, such as bank capital (risk-sharing). We propose a theoretical model to study how 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 interbank activity and its bank capital, independently of whether the bank is a net lender or a net borrower in the interbank market. Finally, we provide strong empirical support for this prediction in a large sample of U.S. banks, as well as in a sample of European and Japanese banks.

*We thank Christa Bouwman, Fabio Braggion, Max Bruche, Hans Degryse, Robert Hauswald, Vasso Ioannidou, Jose Jorge, Enisse Kharroubi, Christian Laux, Marcella Lucchetta, Joao Santos, Steven Ongena, Wolf Wagner and seminar participants at University of Vienna, Norwegian Business School, University of Geneva, University of Bologna, Deutsche Bundesbank Conference "Liquidity and Liquidity Risk", ELSE-UCL Workshop in "Financial Economics: Markets and Institutions", Frias-CEPR Conference "Information, Liquidity and Trust in Incomplete Financial Markets", Fourth Swiss Winter Conference on Financial Intermediation, Fourth Bank of Portugal Conference on Financial Intermediation for helpful comments. We thank Mario Bellia for excellent research assistance. The usual disclaimer applies.

†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.

¶University Ca' Foscari of Venice and MIT. E-mail: pelizzon@unive.it.

JEL Classification: G21.

Keywords: Bank Capital, Interbank Markets, Liquidity Coinsurance.

1 Introduction

The management of liquid resources is an important concern for banks. Indeed, they typically transform short-term liquid liabilities into long-term illiquid assets and are therefore exposed to a substantial amount of liquidity risk. A simple way to tackle this uncertainty is to hold liquid reserves, which amounts to self-insuring against the occurrence of a liquidity shock. This clearly is costly for banks, as they could instead invest in more productive illiquid or risky assets. Alternatively, banks can participate in the interbank markets, where they can exchange resources 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, impossible 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] To the extent that payouts to holders of bank capital are not fixed obligations, bank capital also offers an opportunity to deal with liquidity risk: by adjusting the payouts to bank capital holders, banks can transfer part of the liquidity uncertainty to capital investors. This liquidity risk-sharing function of bank capital, however, also comes at a cost since raising capital is itself costly for banks.[2]

This paper analyzes the interplay between bank capital, interbank market activity, and portfolio choices in a model where banks are subject to 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 in liquid assets. We proceed by first introducing a theoretical model that studies banks' behavior in the presence of interbank markets. The optimal risk-sharing in our model requires that payouts to equity investors are postponed when the interbank market cannot provide liquidity coinsurance. As postponing payouts means higher future payouts to capital investors, our model predicts a negative relationship between the value of bank capital and interbank market activity. We then

[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 [8]).

[2] Alternatively, and similarly to the corporate finance literature, 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 [10], and Morrison and White [25]).

show that this prediction finds strong support in a large sample of U.S. banks, and also in a sample of European and Japanese banks. To our knowledge this is the first empirical attempt to investigate this issue.

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. Their liquidity shocks are sometimes idiosyncratic, but they also face the possibility of receiving a symmetric liquidity shock with some probability. 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 the 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 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 of bank capital.

Banks in our model select the amount of capital they raise before the nature of the liquidity shock is realized. As collecting resources from risk-neutral investors is costly, banks would hold no capital were the liquidity uncertainty purely idiosyncratic. Clearly, the optimal level of bank capital crucially depends on the probability banks place on the liquidity shock being undiversifiable, and thereby uninsurable in the interbank market. We show by means of examples that this relationship might not be monotonic. In fact, while we would expect the optimal level of bank capital to decrease when the probability of an undiversifiable shock reduces, this only happens for some parameter configurations. This is due to the fact that a reduction in the probability of an undiversifiable shock 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. [11], 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

[3] In our analysis banks 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.

can be an important determinant of bank capital.[4]

Unfortunately it is difficult to measure empirically the bank-level undiversifiable liquidity risk. Therefore, to obtain testable implications we make use of the following general insight of the model: payouts to risk-neutral capital investors should not be realized 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 market activity is low. The decision about when to realize a payout clearly affects the value of bank capital. When holders of bank capital are paid, the value of bank capital *ceteris paribus* tends to drop. On the other hand, postponing payouts means higher future payouts to investors, and the value of bank capital should increase as a consequence. Since payouts to bank capital holders occurs (is postponed) when activity in the interbank market is high (low), the model predicts that a bank's activity in the interbank market has a negative correlation with the value of bank capital.

In the empirical part of the paper we test this prediction and find that it is strongly supported by the data. The main results are obtained from a large sample of U.S. commercial banks. We use their Call Reports to build a quarterly panel dataset spanning from the first quarter of 2002 till the fourth 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 markets.

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

[4]To the extent that such risk is a persistent bank characteristic, it might be responsible for at least some of the large explanatory power that bank fixed effects have in regressions explaining banks' capital structure (Gropp and Heider [22]).

(b) are collateralized, and we prefer to focus on the unsecured market considered in (a). In the latter market the role of bank capital as a signal of financial strength should be more relevant and, as a consequence, larger capital buffers should facilitate borrowing activity. Therefore, the negative relationship between bank capital and interbank activity should be harder to detect in (a) than in (b). As for capital, we adopt a broad definition including book values of equity and reserves, as well as preferred stocks and hybrid capital. In this way we intend to include any source of funding with a long maturity and no collateral, whose remuneration is flexible enough to be potentially used to absorb non diversifiable liquidity shocks.

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 specifications of interbank market activity. We run several robustness checks to assess the reliability of our findings, and we also replicate our results in a sample of European and Japanese commercial banks using yearly data from 2005 to 2010. Overall, we consider our evidence as strongly supportive of 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 provides an incentive to avoid excess risk taking, more capital should translate into lower insolvency risk, and should result in easier access to the interbank market. This in turn would imply a positive relationship between the level of bank capital and interbank activity, at least for banks that are net borrowers.

Even if our paper does not directly address normative issues, our results may be relevant for the policy debate. 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, for example, Admati et al. [2]). Clearly, we do not intend to dismiss this important role of bank capital, but our results show that its risk-sharing role is also relevant and has been essentially overlooked so far. Indeed, any intervention to regulate bank capital is likely to affect the functioning of the markets in which banks coinsure their liquidity risk in a non-trivial way.

Our paper is related to both theoretical and empirical works in banking. On the theory side, the paper closest to ours is Gale [20]. He also considers the risk-sharing role of bank capital but, contrary to us, his analysis focuses on regulatory aspects without providing an analysis on the relationship between interbank market activity and bank capital. For this purpose, Gale [20] considers spot markets as a way to co-insure against liquidity shocks. Contrary to him, and similarly to Allen and Gale [5], we model the interbank market as a device to decentralize the first best allocation of risk. In particular, we assume that banks make ex ante arrangements to co-insure themselves. However, following Castiglionesi et al. [11], in our model aggregate uncertainty is perfectly anticipated by economic agents. More importantly, while both in Allen and Gale [5] and Castiglionesi et al. [11] bank capital is ignored, we are able to analyze the interaction between the liquidity insurance provided by the interbank market and by bank capital.[5][6]

On the empirical side, our paper is the first attempt to investigate the relationship between interbank market participation and bank capital. For this reason it relates to two different strands of the literature: the one on bank capital and the other on interbank markets. Flannery and Rangan [15] and Gropp and Heider [22] look at the determinants of banks' capital holdings. Flannery and Rangan [15] argue that the main cause of capital build-up of large U.S. banks in the 1990s was an increased market discipline due to legislative and regulatory changes, resulting in the withdrawal of implicit government guarantees. Gropp and Heider [22] 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 ([16], [17] and [18]) analyzes banks' screening

[5] A number of papers analyzes the functioning of the interbank market in the recent financial crises, among others Acharya et. al.[1]

[6] There is also an extensive theoretical literature on capital regulation based on the incentive function of bank capital. The results are not conclusive since while bank capital requirements usually decrease risk, the reverse is also possible (see Kim and Santomero [24], Furlong and Keeley [19], Gennotte and Pyle [21], Besanko and Kanatas [9] and Hellman et al. [23]). Among the recent contributions, Diamond and Rajan [14] 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 [4] analyze the role of market discipline as a rationale to hold bank capital, but do not consider the liquidity provision role of banks.

and monitoring activity in the Federal Funds market, and the behavior of this market during Russia's sovereign default. Cocco et al. [12] 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. [3] examine the impact of the financial crisis of 2008, specifically the bankruptcy of Lehman Brothers, on the functioning of the Federal Funds market. They argue that while banks became more restrictive in which counterparties they lent to, the financial crisis did not lead to a complete collapse of the Fed Funds market. A comparable analysis has been performed by Angelini et al. [7] for the European interbank market with similar results. 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 participation in the interbank market affects bank capital. Section 6 presents the data we used to test the model's predictions and the results of our regressions. Section 7 concludes. Appendix A contains the proofs, and Appendix B reports the detailed description of the variables and their unconditional correlations.

2 The Model

The basic model is similar to Gale [20], and provides a rationale for the use of bank capital based on risk sharing. There are three dates ($t = 0, 1, 2$) and a single good available at each date for both consumption and investment. Two assets are available for investment: a short-term or liquid asset that matures in one period with a return of one, and a long-term or illiquid asset that requires two periods to mature and delivers a return $R > 1$. The short asset represents a storage technology (one unit of the good invested at $t = 0, 1$ produces one unit at $t + 1$), while the long asset captures long-term productive opportunities (one unit invested at $t = 0$ produces R units at $t = 2$, and nothing at $t = 1$). Clearly, the choice of a portfolio of assets reflects a trade-off between returns and liquidity.

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

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

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

The second group is given by risk-averse agents that we call *depositors*. They are endowed with 1 unit of the consumption good at $t = 0$, and nothing at $t = 1, 2$. Following Diamond and Dybvig [13], depositors can be of two types: early consumers who only value consumption at $t = 1$, or late consumers who only value consumption at $t = 2$. The type of an agent is not known at $t = 0$. When consumption is valuable, the agent's utility is $u(c)$, where $u : \mathbb{R}_+ \to \mathbb{R}$ is continuously differentiable, strictly increasing and concave, and satisfies the Inada condition $\lim_{c \to 0} u'(c) = \infty$. We assume that each bank has a unitary mass of depositors.

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

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

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

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

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	$p/2$

whereas it is clearly ω_H in state HH. Hence, there is some non-diversifiable uncertainty on liquidity needs that is maximum when $p = 1/2$.[7] Notice that, as we assume $p \geq 1/2$, any increase in p represents a reduction in non-diversifiable uncertainty on liquidity needs.

Agents cannot trade directly with one another, but the banking sector makes up for the missing markets. In particular, the activity of each bank develops as follows. At $t = 0$ each bank collects the initial endowment of its depositors and an amount $e \geq 0$ of resources from investors. Therefore, the amount e will henceforth be referred to as bank capital. The bank invests an amount y in the short asset and an amount $1 + e - y$ in the long asset; in period 1, after the aggregate shock S is publicly observed, the consumer reveals his preference shock to the bank and receives the consumption vector $\left(c_1^S, 0\right)$ if he is an early consumer and the consumption vector $\left(0, c_2^S\right)$ if he is a late consumer. Similarly, after the state S has been revealed, investors receive the consumption vector $(d_1^S, d_2^S) \geq 0$.[8] Therefore, a risk sharing contract, also called an allocation, offered by the bank is fully described by an array

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

As in Allen and Gale [5], the existence of different groups of banks with different liquidity needs can capture different level of aggregation. Each bank in the model could indeed correspond to a specific financial institution, or to the representative bank in a specific banking sector, a geographical region, etc. For our purposes, the economy described above represents a set of banks connected through an interbank market together with their depositors and investors. In this sense, the parameter p represents a measure of the

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

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

deepness of the interbank market, as it gives the probability of finding a bank with different liquidity needs to, potentially, trade with. The parameter p may reflect (1) the degree of connectedness of a certain bank to the overall interbank market network; (2) the relative importance of local (and diversifiable) shocks to aggregate shocks; and (3) the cross-border position of the national banking system.

In what follows we are interested in studying the effects of the interbank market on the incentives to hold bank capital. Since our focus will be on an interbank market that is able to decentralize the first-best allocation, we start in the next section to characterize optimal risk sharing and we will introduce the interbank market in Section 4.

3 Optimal Risk Sharing

In this section we abstract from the interbank market and consider optimal risk sharing in a situation where investors are maintained at their reservation utility. We do so, following Gale [20], to capture a situation where investors are perfectly competitive and their supply of capital is perfectly elastic. Hence, we look for the allocation that maximizes the sum of ex-ante expected utilities of depositors and guarantees to investors the utility they could obtain by consuming their endowment at $t = 0$. We also assume that the fraction of early consumers in each bank (i.e., the state of the world) is observable and verifiable, but the preference shocks of individual depositors are not. Notice that the overall fraction of early consumers is the same in states HL and LH, and it is therefore optimal to move resources from one bank to the other to make the agents' consumption plans constant in this case (i.e., $c_t^{HL} = c_t^{LH}$ and $d_t^{HL} = d_t^{LH}$ for $t = 1, 2$).

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

$$\begin{aligned} \omega_s c_1^s + d_1^s &\leq y, & (1)\\ (1-\omega_s)c_2^s + d_2^s &\leq (1+e-y)R + y - \omega_s c_1^s - d_1^s, & (2)\\ p(\rho_1 d_1^M + d_2^M) + (1-p)(\rho_1 d_1^H + d_2^H) &\geq \rho_0 e. & (3)\end{aligned}$$

The first two constraints guarantee that there are enough resources at $t = 1$ and $t = 2$ respectively, to deliver the planned amount of consumption in each state s. Whenever

$y - \omega_s c_1^s - d_1^s > 0$ we say that there is positive rollover in state s, that is, some resources are stored through the liquid asset between $t = 1$ and $t = 2$. In this case the ex-post social value of liquidity is clearly the lowest possible as it exceeds the overall needs. The third constraint guarantees that investors get at least their reservation utility.[9] To characterize optimal risk sharing, we can think of a planner choosing 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 bank's consumption needs must be satisfied with the resources available within the bank. In fact, in state H, both banks have a total demand for liquidity (from both consumers and investors) equal to $\omega_H c_1^H + d_1^H$ and from (1) we see that the available amount of the short asset within each bank is in fact enough to satisfy the internal demand (i.e., $y \geq \omega_H c_1^H + d_1^H$). Things are different in state M: in this case in order to implement the first best, the planner has to move resources between the two banks. For example, with no rollover in state M, the amount of liquid resources available at $t = 1$ in both banks is $\omega_M c_1^M + d_1^M$. However, one bank has a fraction ω_H of early consumers so that its demand for liquidity is $\omega_H c_1^M + d_1^M$, which results in an excess demand of $(\omega_H - \omega_M) c_1^M$. At the same time, the other bank has a fraction ω_L of early consumers so that its demand for liquidity is only $\omega_L c_1^M + d_1^M$, which results in an excess supply of $(\omega_M - \omega_L) c_1^M$. Given that

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

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

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

4 Interbank Deposit Market

Consider now the decentralized economy in which each bank directly offers a risk-sharing contract to its depositors and investors. We would like to know whether optimal risk

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

sharing can also be achieved in this case. We assume that the banking sector is perfectly competitive and, as a result, banks maximize the ex-ante utility of their depositors.[10] This assumption in turn ensures that the decentralized economy achieves optimal risk sharing if and only if the optimal allocation is feasible for each bank, separately. The first-best consumption levels would not entail any feasibility problem in state H as, in this case, each bank's demand for consumption is entirely satisfied using internal resources.[11] However, in state M both at $t = 1$ and $t = 2$, one bank has an excess demand for consumption while the other bank has an excess supply of exactly the same amount.

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

We can now verify that the first-best allocation is feasible in the decentralized economy with interbank markets. To this end, notice that at $t = 0$ the net flow of funds between the two banks is zero so that the first-best level of capital e and liquidity y are still compatible

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

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

with the first-best level of investment in the long asset given by $1+e-y$. Thereafter, at $t=1$ in state H the two banks withdraw their deposits at the same time so that the net flow of funds between banks is zero both at $t=1$ and $t=2$. First-best consumption levels are feasible within each bank in state H and will therefore remain so also in the presence of the interbank deposits market. In state M the two banks receive asymmetric liquidity shocks so that one bank will withdraw its interbank deposit at $t=1$ (the bank with the 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).[12] 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.

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

Table 2: Net interbank flows and positions

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

5 First-Best Allocation

In this section we further characterize the first-best allocation and we study the role of both bank capital and interbank deposit in achieving optimal risk sharing. In a nutshell, interbank markets can only work when bank liquidity needs are asymmetric, that is in state M. The existence of undiversifiable liquidity uncertainty (i.e., the possibility of liquidity shocks that cannot be diversified away through the interbank market) creates a scope for bank capital. In fact, by raising bank capital, part of this undiversifiable risk can be transferred to risk-neutral investors. The following result summarizes some basic properties of the first-best allocation.

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

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

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

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

In principle, banks could raise enough capital to completely insure depositors against liquidity uncertainty, but this turns out to be suboptimal because bank capital is costly. In fact, when $c_2^H = c_2^M$, 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 [6]) and this makes the use of bank capital costly. To conclude this section notice that the first-best level of capital may be zero. This trivial case emerges for example if ρ_0 is too large with respect to ρ_1, and bank capital becomes too costly to be used for risk-sharing purposes. In what follows we therefore exclude this case.

5.1 Bank Capital

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

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

subject to

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

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

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

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

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

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

[FIGURE 1]

Surprisingly, however, the negative relationship between the level of bank capital and p is not a general property of the model. This result can be explained since, as shown in Castiglionesi et al. [11] for the case without bank capital, a reduction in the undiversifiable liquidity uncertainty (i.e., an increase in p) can induce a bank to reduce its liquidity ratio and, in some cases, this can ultimately lead to a higher consumption volatility. A similar effect shows up in this case, and can induce banks to increase their capital to moderate the increased consumption volatility brought about by the smaller liquidity ratio induced by a larger p. Eventually, bank capital decreases with p as it approaches one (i.e., as the overall liquidity uncertainty tends to vanish).

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

[FIGURE 2]

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

5.2 Bank Capital and Interbank Market Activity

The relationship between bank capital and p is intuitive but difficult to study empirically because of the unobservability of p. What we do observe is a bank's activity in the interbank market at $t = 1$ which is captured by π_1^s, 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 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, since it also determines banks' net position in the interbank market, 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. Banks' transactions on the interbank market typically take place over the counter and detailed data are not publicly available. However, information on banks' interbank activity can be obtained from the quarterly Federal Financial Institutions Examination Council (FFIEC) Reports of Condition and Income (briefly, "Call Reports"), which all regulated commercial banks file with their primary regulator. Call Reports contain detailed on- and off-balance-sheet information for all banks.[13] We build a quarterly panel dataset spanning from the first quarter of 2002 to the fourth quarter of 2010. Our

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

sample consists of an unbalanced panel of 3,325 banks.[14] Therefore, after excluding banks that do not report their interbank market exposure or their capital we end up with a sample of 3,325 banks.

To measure the activity of a bank on the interbank market, we consider the position a bank has vis-a-vis other banks at the time of the quarterly balance-sheet closure. We look at three different types of interbank transactions: (a) Unsecured interbank lending and borrowing; (b) Securities purchased under agreements to resell and securities sold under agreements to repurchase, i.e. Repos and Reverse Repos, with a maturity longer than one day; (c) Lending and borrowing on the overnight Federal Funds market that also includes overnight Repos. In Section 6.2 we focus our analysis on the unsecured interbank lending and borrowing positions normalized by total assets (*Interbank_ a*) and the overall interbank activity, adding Repo and Fed Funds positions to those in the unsecured market, normalized by total assets (*Interbank_ abc*). We take the absolute value of the difference between borrowing and lending positions as the empirical counterpart of $|\pi_1|$. We use the absolute value since we are rather interested in the bank's overall activity in the interbank market than whether a bank is a net borrower or a net lender.

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

To test the contemporaneous negative relationship between a bank's activity in the interbank market and the level of its capital (Proposition 3), we include a series of balance-sheet variables to control for other factors that might induce a spurious correlation.[15] Indeed, other variables can affect the determination of bank capital and the ability of a bank to borrow (and in general to be active) in the interbank markets.

The first set of control variables contains measures related to the liquidity holding of banks. The first variable is cash and government securities (*Liquidity*), while the second

[14]The FFIEC repository database contains information on 10,092 banks, however, the majority of them have total assets below $300 million, and those are not required to report information on short term bank lending and borrowing.

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

is the amount of money deposited with the FED (*DepositsFED*). We also control for the amount of deposits (*Deposits*) a bank has. The second set of control variables consists of two measures that capture the riskiness of a bank: the first variable is the amount of outstanding loans (*Loans*) and the second variable is risk-weighted assets (*RWA*). Furthermore, we include the return on assets (*ROA*) to capture the impact of a bank's profitability on the relationship between bank capital and interbank market activity. All the previous control variables are normalized by total assets. We also control for bank size (*Size*), measured by total assets.

Finally, the activity of an individual bank in the interbank market can be affected by the size of the market itself. We use three proxies for the size of the interbank market. First, for each bank we calculate the total amount lent and borrowed in the interbank market by other banks located in the same state as a given bank, normalized by their total assets (*Other_Banks_Lend* and *Other_Banks_Borrow*, respectively). Second, for each bank we calculate the liquidity holdings of other banks located in the same state as a given bank, normalized by their total assets (*Other_Banks_Liquidity*).

Table 4 provides descriptive statistics for our main variables, and shows that the sample exhibits considerable heterogeneity. The average unsecured interbank market activity (*Interbank_a*) is 2.38% of total assets in our sample. The median is 0.92% of total assets.[16] Including Repos and Fed Funds, the average interbank activity (*Interbank_abc*) becomes 5.63% of total assets with a median of 3.15%. Notice that the dispersion is rather significant: the variable *Interbank_a* ranges from 0.03% for the 5th percentile to 8.71% for the 95th percentile, and if we consider *Interbank_abc* the dispersion is even larger (0.18% to 18.71%). The same applies to bank capital. On average the variable *Capital* is 10.8% of total assets but the standard deviation is 7.61%. Finally, notice that the mean of the variable *Size* is $5,055 million and the median is $566 million. The sample therefore includes large, medium, and small banks.

[TABLE 4]

[16] Only banks with total assets of at least $300 million must report their positions on the unsecured interbank market, otherwise they have discretion to report this information. Banks with total assets below $300 million represent 15% of our sample of 3,325 banks. We present the results with the sample of all banks that report the information, however all our results (with one exception, see Section 6.3) still hold if we exclude banks with total assets below $300 million.

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 between these two variables.[17] In the basic specification, we perform the following panel regression:

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

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, $\mathbf{X}_{i,t}$ 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 [26]). 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 of the variable *Capital* is -0.096 in regression (1), where the dependent variable is *Interbank_ a*. The same coefficient is -0.08 in regression (3) where the dependent variable is *Interbank_ abc*. These coefficients are significant at the 1% and 5% levels, respectively. The economic significance of these estimates seems relevant as well. For example, in regression (1) a one-standard-deviation increase in the amount of bank capital is associated with a reduction of 0.73% in interbank activity, which represents 30% of its mean and as much as 80% of its median.

The control variables have the expected sign and some of them are also significant. In particular, the variables *Liquidity* and *DepositsFED* are negatively related to interbank market activity. Both these variables are significant at the 1% level. Including the three proxies for the size of the interbank market (regressions (2) and (4) in Table 5) does not

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

affect our results. The variables *Other_ Banks_ Lend* and *Other_ Banks_ Borrow* have an insignificant coefficient. The variable *Other_ Banks_ Liquidity* 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 hold on to more liquid assets.

Our empirical results give support to the predictions of the theoretical part of the paper and hence provide evidence on the risk-sharing role of bank capital. Note that theories that view bank capital as an indicator of solvency would yield a positive relationship between bank capital and interbank market activity.

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. Our model points to a general mechanism without delivering different predictions for crisis and non-crisis periods. However, the relationship between bank capital and interbank market activity might be affected in a crisis period by other factors that are not captured by our model. Indeed, from the third quarter of 2007, the interbank markets were affected by one of the strongest financial crises 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 second quarter of 2007, while the rest of the sample period is considered as the crisis period. Table 6 shows that the predicted negative relationship is present both in the pre-crisis and in the crisis periods. The coefficient of the variable *Capital* is negative and significant in both cases. However, the coefficient in the post-crisis period is larger indicating that the liquidity coinsurance role of capital, i.e., the fact that capital and interbank market are substitute, is more relevant.[18]

[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. The negative relationship we find

[18] A similar result is obtained if we consider the start of the crisis period in the third quarter of 2008.

between bank capital and interbank market activity could be driven by banks with low (or high) levels of activity in the interbank market. Therefore we split our sample into two subsamples containing banks with interbank market activity below and above the sample median, respectively.[19] Table 7 shows that the negative relationship between bank capital and interbank market activity holds independently of the level of activity. When we use *Interbank_ a* to measure interbank activity, the coefficient of the variable *Capital* 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. Notice that the value of the coefficient is smaller for banks with low levels of activity in the interbank market. When we use *Interbank_ abc* to measure interbank activity, the coefficient of the variable *Capital* remains significant at the 1% for banks with an interbank activity higher than the median while the same coefficient is significant at the 10% for banks with low levels of activity in the interbank market.

[TABLE 7]

Constrained vs. unconstrained banks. Even if in our theoretical model regulation plays no role, in practice banks face capital regulation. Hence, it is conceivable that a bank's ability to use its payout policy to deal with liquidity uncertainty is affected by how close it is to the regulatory capital requirement. Table 8 provides regression results for banks that hold a total regulatory capital ratio above 10% and for banks that hold a total regulatory capital ratio below 10%.[20] Regressions (2) and (4) in Table 8 show that with both measures of interbank activity the coefficient of the variable *Capital* is negative and significant at the 1% for banks with a capital ratio lower than 10%. Banks with a capital ratio higher than 10% display a negative coefficient of the variable *Capital* that is significant at the 5% when we use *Interbank_ a* (regression (1)) and at the 10% when we use *Interbank_ abc* (regression (3)). Moreover, the coefficient of the variable *Capital* is larger for banks that hold a capital ratio less than 10% than for those banks that are above this value.

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

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

[TABLE 8]

Alternative interbank-market selection. We now check to what extent the negative relationship between bank capital and interbank activity holds when we consider the Repo (*Interbank_ b*) and Fed Funds (*Interbank_ c*) markets separately. We report summary statistics for these two markets in Table 9, and regression results in Table 10.[21]

[TABLES 9 AND 10]

Regression (1) in Table 10 shows that when we consider *Interbank_ b* as an dependent variable the predicted negative relationship still holds, and the coefficient of the variable *Capital* is significant at the 1% level. When we use *Interbank_ c* as dependent variable (regression (2)), the coefficient of the variable *Capital* is insignificant. One possible explanation for this result might be that banks use the overnight market mainly to deal with highly transitory liquidity shocks. As payouts to investors are usually realized quarterly, it is less likely that the payout policy can efficiently be used to absorb transitory liquidity shocks. In this sense a flexible payout policy might be a poor substitute for overnight markets.[22]

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

Alternative measure of interbank activity. A possible drawback of the net interbank position in a given quarter is its dependence on the net position in previous quarters,

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

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

and this might lead to a distorted assessment of interbank activity.[23] We then consider the sum of the borrowing and lending positions in the interbank market as an alternative measure of interbank activity. Notice that this alternative measure might be misleadingly large for banks that, apart from insuring their own liquidity shocks, also act as intermediaries in the market and take, possibly large, borrowing and lending positions at the same time. Consistently with the previous analysis, we indicate with *Sum_ Interbank_ a* and *Sum_ Interbank_ abc* the two measures of interbank activity. Their summary statistics are reported in Table 9. Table 11 shows that also in this case, the coefficient of the variable *Capital* is negative and significant in all specifications.[24]

[TABLE 11]

Bankscope data. Finally we perform a robustness check of our results by using data on non-U.S. banks. To our knowledge, there is no database available with quarterly balance-sheet information on non-U.S. banks. Bankscope provides yearly balance-sheet information for a large sample of banks in different countries. We use this dataset to investigate interbank market activity for European and Japanese commercial banks. We consider a sample of 863 banks for the period 2005 to 2010. The data does not allow us to distinguish between various forms of interbank markets such as the unsecured interbank market and Repos. Hence, our interbank market activity variable (*Interbank*) includes both.[25] 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 what we observe for U.S. banks. The average level of capitalization is instead lower and less dispersed than in the U.S. sample.

[TABLE 12]

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

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

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

The results of the panel estimation of equation (10) with the Bankscope data 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. Nevertheless, we still find a negative and significant coefficient of the variable *Capital*. Notice that the coefficient of the variable *Other_ Banks_ Borrow* is positive and significant, that is, a bank's interbank activity is positively related to the overall interbank borrowing activity of the country it belongs to. This result is in contrast with what was found for U.S. banks, where the overall activity at the state level was found to be insignificant.

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

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

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

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

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

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

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

The policies C_1 and C_2 are given by

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

Proof. To show the strict concavity of the value function note that if $c = (c_1, c_2)$ and $c' = (c'_1, c'_2)$ are optimal with $\xi = (y, e, d_1, d_2, \omega)$ and, respectively, $\xi' = (y', e', d'_1, d'_2, \omega)$, then given $\alpha \in (0,1)$, $c^\alpha = \alpha c + (1-\alpha)c'$ is feasible for $\xi^\alpha = \alpha\xi + (1-\alpha)\xi'$. Now, the strict concavity of u implies that if $\xi \neq \xi'$ then also $c \neq c'$ and, therefore, the strict concavity of V follows from the strict concavity of u. Continuity follows from the theorem of the maximum, and differentiability follows using concavity and a standard perturbation argument to find a differentiable function which bounds V from below. To obtain (12), note that from the envelope theorem

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

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

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

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

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

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

we distinguish two cases:

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

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

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

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

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

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

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

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

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

subject to

$$\begin{aligned} p\left(\rho_1 d_1^M + d_2^M\right) + (1-p)\left(\rho_1 d_1^H + d_2^H\right) &\geq \rho_0 e; & (16) \\ (d_1^s, d_2^s) &\geq 0;\ s = H, M & (17) \\ e &\geq 0. & (18) \end{aligned}$$

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

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

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

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

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

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

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

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

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

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

The proof is now organized in three steps.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

whereas in the case of a rollover in state M we obtain

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

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

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

whereas in the case of a rollover in state M we obtain

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

■

8 Appendix B: Variable Description

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

[TABLE B1]

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

[TABLES B2, B3 AND B4]

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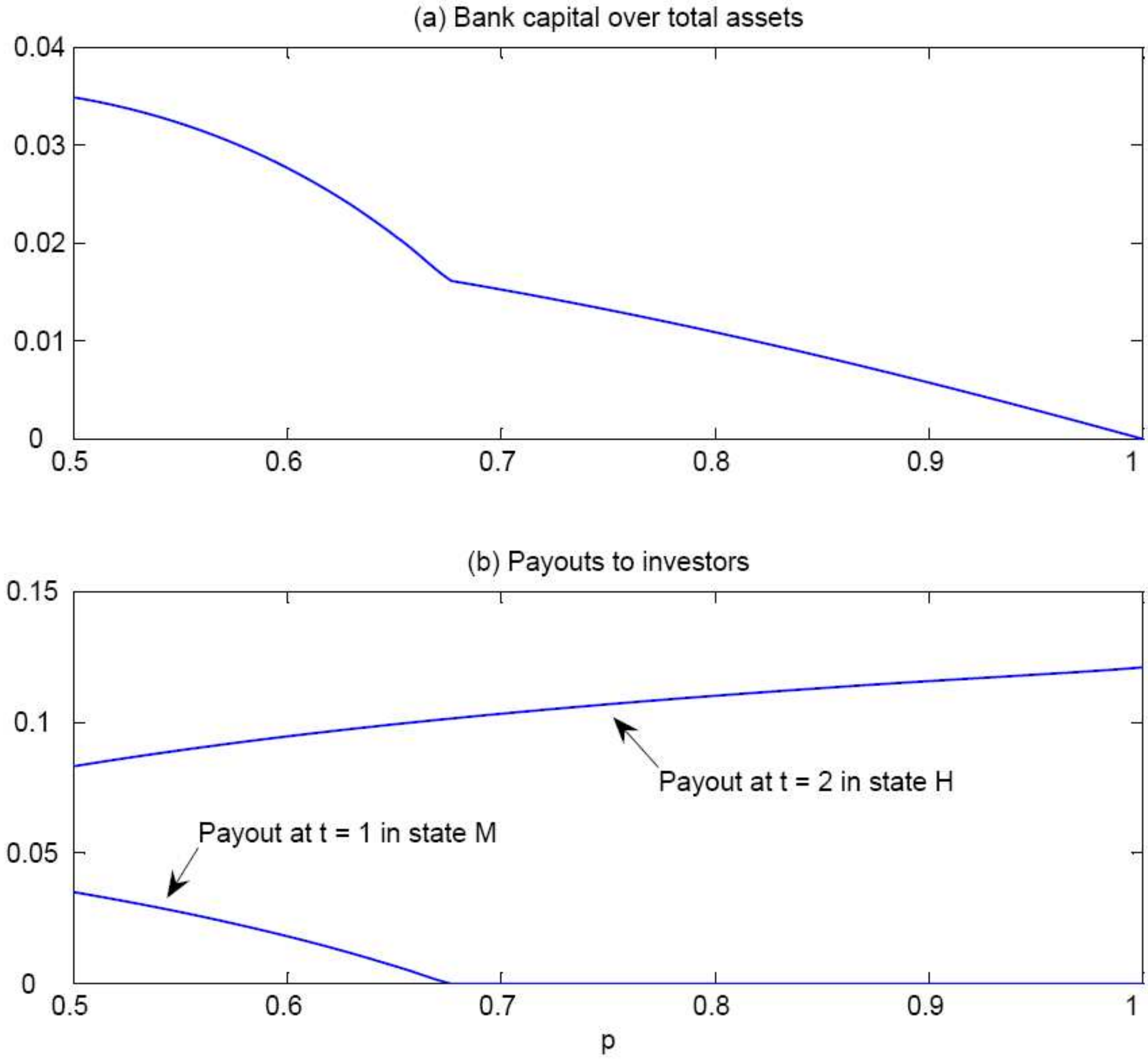
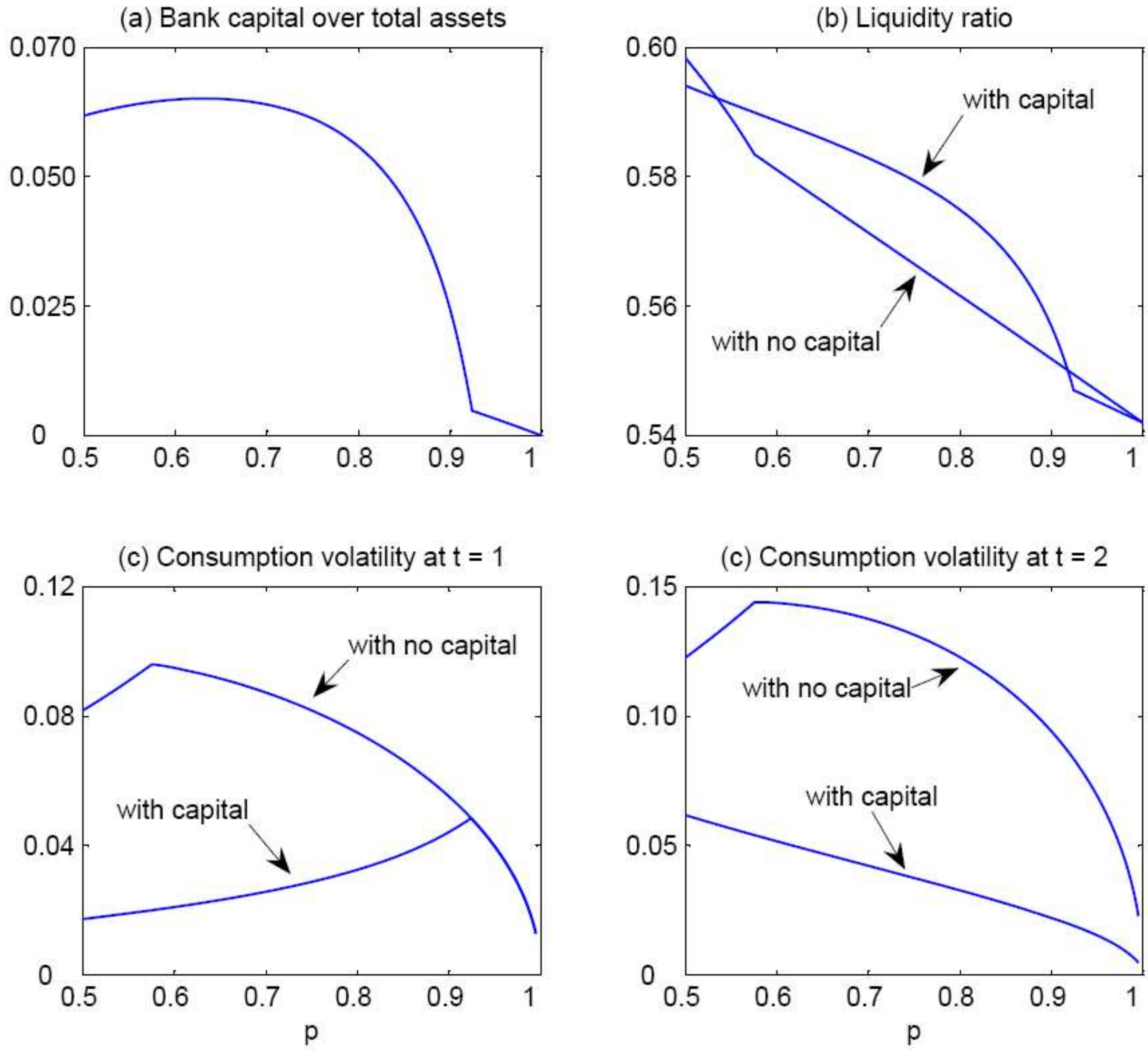
Figure 1 – Bank capital and payouts for different values of p



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

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



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

Table 4 – Summary statistics (I)

Variable	Mean	Stan. Dev.	p5%	Median	p95%
Interbank_a	2.38%	5.83%	0.03%	0.92%	8.71%
Interbank_abc	5.63%	8.62%	0.18%	3.15%	18.71%
Capital	10.80%	7.61%	6.54%	9.28%	17.81%
DepositsFED	1.28%	3.62%	0.00%	0.19%	6.44%
RWA	72.37%	15.31%	45.94%	73.86%	92.95%
Liquidity	18.96%	13.00%	1.49%	16.81%	42.92%
Loans	66.62%	16.58%	34.63%	69.75%	87.06%
Deposits	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
Other_Banks_Lend_a	1.27%	1.29%	0.35%	1.00%	3.14%
Other_Banks_Borrow_a	0.51%	0.51%	0.03%	0.37%	1.47%
Other_Banks_Lend_abc	4.17%	3.33%	1.13%	3.18%	10.76%
Other_Banks_Borrow_abc	6.71%	3.90%	2.57%	5.98%	13.06%
Other_Banks_Liquidity	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

	Interbank_a						Interbank_abc					
	(1)			(2)			(3)			(4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.096	0.033	***	-0.096	0.033	***	-0.081	0.038	**	-0.082	0.038	**
DepositsFED	-0.138	0.045	***	-0.139	0.045	***	-0.448	0.049	***	-0.449	0.049	***
RWA	0.001	0.013		0.000	0.013		-0.024	0.013	*	-0.024	0.013	*
Liquidity	-0.143	0.015	***	-0.144	0.016	***	-0.310	0.023	***	-0.310	0.023	***
Loans	-0.153	0.021	***	-0.153	0.022	***	-0.376	0.023	***	-0.377	0.023	***
Deposits	-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	***
Other_Banks_Lend_a				0.017	0.018							
Other_Banks_Borrow_a				0.130	0.091							
Other_Banks_Lend_abc										-0.019	0.013	
Other_Banks_Borrow_abc										0.017	0.019	
Other_Banks_Liquidity				-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 *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list 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

	Interbank_a						Interbank_abc					
	Pre-Crisis (1)			Crisis (2)			Pre-crisis (3)			Crisis (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.047	0.024	**	-0.190	0.062	***	-0.105	0.047	**	-0.155	0.049	***
DepositsFED	-0.404	0.097	***	-0.243	0.065	***	-0.550	0.097	***	-0.485	0.056	***
RWA	0.001	0.017		-0.018	0.018		-0.029	0.016	*	-0.035	0.017	*
Liquidity	-0.133	0.020	***	-0.231	0.040	***	-0.356	0.031	***	-0.370	0.043	***
Loans	-0.147	0.035	***	-0.257	0.042	***	-0.430	0.034	***	-0.443	0.037	***
Deposits	-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	***
Other_Banks_Lend_a	0.015	0.014		0.021	0.043							
Other_Banks_Borrow_a	0.070	0.128		-0.042	0.112							
Other_Banks_Lend_abc							-0.026	0.016		-0.011	0.024	
Other_Banks_Borrow_abc							0.020	0.019		0.028	0.023	
Other_Banks_Liquidity	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	37,421			29,253			37,421			29,253		
N. of clusters	2,824			2,564			2,824			2,564		
Sample period	2002 Q1: 2007 Q2			2007 Q3: 2010 Q4			2002 Q1: 2007 Q2			2007 Q3: 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 – 2007Q2) and crisis period (2007Q3 – 2010Q4). Interbank market activity is measured in *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending position of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list 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

	Interbank_a						Interbank_abc					
	High Activity (>50°) (1)			Low Activity (<50°) (2)			High Activity (>50°) (3)			Low Activity (<50°) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.129	0.048	***	-0.019	0.004	***	-0.124	0.051	***	-0.048	0.029	*
DepositsFED	-0.187	0.062	***	-0.018	0.005	***	-0.515	0.064	***	-0.190	0.020	***
RWA	0.005	0.021		-0.004	0.002		-0.020	0.021		-0.015	0.010	
Liquidity	-0.209	0.024	***	-0.023	0.003	***	-0.370	0.030	***	-0.139	0.018	***
Loans	-0.221	0.031	***	-0.018	0.004	***	-0.456	0.028	***	-0.151	0.018	***
Deposits	-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	**
Other_Banks_Lend_a	0.075	0.068		0.000	0.005							
Other_Banks_Borrow_a	0.199	0.165		0.038	0.035							
Other_Banks_Lend_abc							-0.052	0.026	**	0.009	0.007	
Other_Banks_Borrow_abc							0.045	0.036		-0.008	0.009	
Other_Banks_Liquidity	-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 *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list 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

	Interbank_a						Interbank_abc					
	Unconstrained (CapitalRatio>10%) (1)			Constrained (CapitalRatio<10%) (2)			Unconstrained (CapitalRatio>10%) (3)			Constrained (CapitalRatio<10%) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.080	0.034	**	-0.831	0.201	***	-0.069	0.039	*	-0.768	0.175	***
DepositsFED	-0.129	0.029	***	-0.040	0.085		-0.437	0.044	***	-0.117	0.088	
RWA	0.003	0.012		-0.043	0.051		-0.022	0.014		-0.032	0.049	
Liquidity	-0.138	0.015	***	-0.036	0.073		-0.307	0.024	***	-0.132	0.078	*
Loans	-0.149	0.022	***	-0.016	0.073		-0.375	0.024	***	-0.139	0.082	*
Deposits	-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	
Other_Banks_Lend_a	0.007	0.015		0.718	0.536							
Other_Banks_Borrow_a	0.109	0.089		-0.245	0.783							
Other_Banks_Lend_abc							-0.021	0.013		0.125	0.097	
Other_Banks_Borrow_abc							0.017	0.019		-0.036	0.109	
Other_Banks_Liquidity	-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 *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list 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%
Interbank_b	2.38%	4.82%	0.00%	0.54%	9.51%
Interbank_c	2.84%	5.46%	0.00%	1.14%	10.60%
Interbank_ab	3.90%	7.18%	0.07%	1.82%	13.59%
Fed_Fund_Asset	2.22%	4.91%	0.00%	0.40%	9.15%
Fed_Fund_Liability	0.95%	3.65%	0.00%	0.00%	4.66%
Other_Banks_Lend_b	2.30%	2.72%	0.47%	1.47%	7.35%
Other_Banks_Borrow_b	4.23%	2.75%	1.11%	3.60%	8.89%
Other_Banks_Lend_c	3.09%	2.27%	0.84%	2.56%	6.91%
Other_Banks_Borrow_c	3.00%	3.26%	0.49%	2.24%	8.25%
Other_Banks_Lend_ab	2.30%	2.72%	0.47%	1.47%	7.35%
Other_Banks_Borrow_ab	4.23%	2.75%	1.11%	3.60%	8.89%
Sum_Interbank_a	2.86%	6.31%	0.05%	1.18%	10.81%
Sum_Interbank_abc	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

	Interbank_b (1)			Interbank_c (2)			Interbank_ab (3)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.081	0.025	***	0.018	0.034		-0.154	0.036	***
DepositsFED	-0.129	0.029	***	-0.342	0.036	***	-0.360	0.048	***
RWA	0.025	0.014	*	-0.047	0.012	***	0.012	0.017	
Liquidity	-0.038	0.018	**	-0.215	0.019	***	-0.240	0.028	***
Loans	-0.131	0.032	***	-0.189	0.025	***	-0.335	0.035	***
Deposits	-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	***
Other_Banks_Lend_b	-0.014	0.013							
Other_Banks_Borrow_b	0.064	0.027							
Other_Banks_Lend_c				0.010	0.014				
Other_Banks_Borrow_c				0.003	0.012				
Other_Banks_Lend_ab							-0.023	0.014	
Other_Banks_Borrow_ab							0.039	0.039	
Other_Banks_Liquidity	-0.008	0.009		0.003	0.010		-0.029	0.011	**
Fed_Fund_Asset							-0.330	0.034	***
Fed_Fund_Liability							-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. *Interbak_b* is the banks' activity in the markek for Repos with maturities longer than one day. *Interbank_c* is the banks' activity in the overnight market, including overnight Fed Funds and overnight Repos. *Interbank_ab* is the banks' activity on the unsecured interbank market and on the market for Repos with maturities longer than one day. In each case, the activity is measured as the absolute value of the difference between the borrowing and lending positions. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list 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

	Sum_Interbank_a						Sum_Interbank_abc					
	(1)			(2)			(3)			(4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.111	0.032	***	-0.112	0.032	***	-0.252	0.048	***	-0.253	0.048	**
DepositsFED	-0.148	0.045	***	-0.148	0.045	***	-0.704	0.036	***	-0.704	0.036	***
RWA	-0.001	0.014		-0.002	0.013		-0.019	0.018		-0.019	0.018	
Liquidity	-0.159	0.016	***	-0.160	0.016	***	-0.466	0.029	***	-0.467	0.029	***
Loans	-0.163	0.021	***	-0.164	0.021	***	-0.536	0.026	***	-0.536	0.026	***
Deposits	-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	***
Other_Banks_Lend_a				0.024	0.020							
Other_Banks_Borrow_a				0.127	0.096							
Other_Banks_Lend_abc										-0.015	0.014	
Other_Banks_Borrow_abc										0.029	0.021	
Other_Banks_Liquidity				-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 *Sum_Interbank_a* as the sum of the absolute value of the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Sum_Interbank_abc* adds the Repo and Fed Fund positions t*o Sum_Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list 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%
Interbank	12.97%	16.48%	0.68%	6.84%	50.24%
Capital	7.88%	4.92%	2.67%	6.60%	17.92%
RWA	67.20%	52.72%	25.18%	59.17%	107.62%
Liquidity	4.59%	9.11%	0.00%	0.29%	23.15%
Loans	63.94%	21.96%	13.89%	68.70%	90.62%
Deposits	56.97%	27.88%	0.61%	59.15%	93.06%
ROA	0.59%	1.22%	-0.59%	0.47%	1.95%
Size ($ million)	65,477	291,715	8	1,507	292,400
Other_Banks_Lend	13.02%	5.19%	6.11%	13.48%	20.56%
Other_Banks_Borrow	14.50%	7.60%	0.55%	16.49%	24.05%
Other_Banks_Liquidity	7.96%	5.79%	1.15%	6.60%	21.74%

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

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

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

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

Table B1 – Variable Description

PANEL A: U.S. quarterly data from FFIEC

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

Table B1 – Variable Description (Cont.)

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

PANEL B: EU and Japanese yearly data from Bankscope

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

Table B2 – Correlation matrix for Table 5

	Interbank_a	Interbank_abc	Capital	DepositsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend_a	Other_Banks_Borrow_a	Other_Banks_Lend_abc	Other_Banks_Borrow_abc	Other_Banks_Liquidity
Interbank_a	1.000														
Interbank_abc	0.624	1.000													
Capital	0.325	0.330	1.000												
DepositsFED	0.046	-0.008	0.004	1.000											
RWA	-0.127	-0.259	-0.145	-0.120	1.000										
Liquidity	-0.145	-0.050	-0.062	-0.089	-0.482	1.000									
Loans	-0.190	-0.351	-0.297	-0.124	0.714	-0.624	1.000								
Deposits	-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					
Other_Banks_Lend_a	-0.003	0.014	0.000	0.002	-0.064	0.055	-0.067	-0.015	0.013	-0.015	1.000				
Other_Banks_Borrow_a	0.050	0.036	-0.018	0.085	0.055	-0.061	0.027	0.062	-0.076	-0.010	-0.038	1.000			
Other_Banks_Lend_abc	-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		
Other_Banks_Borrow_abc	-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	
Other_Banks_Liquidity	-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	Interbank_b	Capital	DepositsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend_b	Other_Banks_Borrow_b	Other_Banks_Liquidity
Interbank_b	1.000											
Capital	-0.025	1.000										
DepositsFED	-0.042	0.004	1.000									
RWA	-0.191	-0.145	-0.120	1.000								
Liquidity	0.193	-0.062	-0.089	-0.482	1.000							
Loans	-0.257	-0.297	-0.124	0.714	-0.624	1.000						
Deposits	-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			
Other_Banks_Lend_b	0.040	0.020	-0.009	-0.075	0.062	-0.084	-0.047	0.023	0.080	1.000		
Other_Banks_Borrow_b	0.188	-0.073	-0.062	-0.090	0.065	-0.043	-0.048	-0.014	0.038	0.347	1.000	
Other_Banks_Liquidity	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	Interbank_c	Capital	DepositsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend_c	Other_Banks_Borrow_c	Other_Banks_Liquidity
Interbank_c	1.000											
Capital	0.175	1.000										
DepositsFED	-0.066	0.004	1.000									
RWA	-0.131	-0.145	-0.120	1.000								
Liquidity	-0.075	-0.062	-0.089	-0.482	1.000							
Loans	-0.193	-0.297	-0.124	0.714	-0.624	1.000						
Deposits	-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			
Other_Banks_Lend_c	0.049	0.000	-0.090	-0.056	0.081	-0.073	-0.029	0.057	0.023	1.000		
Other_Banks_Borrow_c	0.037	0.048	-0.038	0.084	-0.037	0.042	-0.035	0.033	0.005	-0.008	1.000	
Other_Banks_Liquidity	-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: Unsecured+Repo	Interbank_ab	Capital	Fed_Fund_Asset	Fed_Fund_Liability	DepoitsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend_ab	Other_Banks_Borrow_ab	Other_Banks_Liquidity
Interbank_ab	1.000													
Capital	0.265	1.000												
Fed_Fund_Asset	0.036	0.183	1.000											
Fed_Fund_Liability	0.011	0.008	0.033	1.000										
DepositsFED	0.018	0.004	-0.064	0.000	1.000									
RWA	-0.214	-0.145	-0.173	0.040	-0.120	1.000								
Liquidity	-0.006	-0.062	-0.067	-0.037	-0.089	-0.482	1.000							
Loans	-0.305	-0.297	-0.256	0.022	-0.124	0.714	-0.624	1.000						
Deposits	-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			
Other_Banks_Lend_ab	0.023	0.020	0.012	-0.006	-0.009	-0.075	0.062	-0.084	-0.047	0.023	0.080	1.000		
Other_Banks_Borrow_ab	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	
Other_Banks_Liquidity	-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	Sum_Interbank_a	Sum_Interbank_abc	Capital	DepositsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend_a	Other_Banks_Borrow_a	Other_Banks_Lend_abc	Other_Banks_Borrow_abc	Other_Banks_Liquidity
Sum_Interbank_a	1.000														
Sum_Interbank_abc	0.613	1.000													
Capital	0.300	0.263	1.000												
DepositsFED	0.052	-0.020	0.004	1.000											
RWA	-0.100	-0.224	-0.145	-0.120	1.000										
Liquidity	-0.165	-0.061	-0.062	-0.089	-0.482	1.000									
Loans	-0.159	-0.354	-0.297	-0.124	0.714	-0.624	1.000								
Deposits	-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					
Other_Banks_Lend_a	-0.007	0.017	0.000	0.002	-0.064	0.055	-0.067	-0.015	0.013	-0.015	1.000				
Other_Banks_Borrow_a	0.065	0.040	-0.018	0.085	0.055	-0.061	0.027	0.062	-0.076	-0.010	-0.038	1.000			
Other_Banks_Lend_abc	-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		
Other_Banks_Borrow_abc	-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	
Other_Banks_Liquidity	-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 Bankscope data

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

FURTHER ROBUSTNESS CHECKS

NOT FOR PUBLICATION

(AVAILABLE UPON REQUEST)

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

	Interbank_a						Interbank_abc					
	High Activity (>75°) (1)			Low Activity (<25°) (2)			High Activity (>75°) (3)			Low Activity (<25°) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.240	0.067	***	-0.004	0.002	*	-0.155	0.068	**	-0.040	0.015	***
DepositsFED	-0.282	0.083	***	-0.002	0.003		-0.555	0.080	***	-0.143	0.024	***
RWA	-0.013	0.023		-0.001	0.001		-0.010	0.030		-0.006	0.006	
Liquidity	-0.292	0.036	***	-0.007	0.002	***	-0.409	0.041	***	-0.101	0.019	***
Loans	-0.310	0.042	***	-0.006	0.002	***	-0.524	0.034	***	-0.108	0.021	***
Deposits	-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	
Other_Banks_Lend_a	0.231	0.146		0.001	0.002							
Other_Banks_Borrow_a	0.258	0.294		0.043	0.021	**						
Other_Banks_Lend_abc							-0.082	0.050		-0.004	0.005	
Other_Banks_Borrow_abc							0.072	0.065		-0.011	0.010	
Other_Banks_Liquidity	-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	16,671			16,678			16,660			16,680		
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 *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and as time dummies. For each model specification we list 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_Interbank_a						Sum_Interbank_abc					
	Pre-Crisis (1)			Crisis (2)			Pre-crisis (3)			Crisis (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.047	0.020	**	-0.201	0.032	***	-0.246	0.048	***	-0.306	0.054	***
DepositsFED	-0.313	0.053	***	-0.168	0.022	***	-0.870	0.142	***	-0.737	0.038	***
RWA	0.002	0.012		-0.031	0.011	***	-0.054	0.020	***	-0.039	0.021	*
Liquidity	-0.123	0.014	***	-0.188	0.019	***	-0.516	0.033	***	-0.549	0.041	***
Loans	-0.122	0.019	***	-0.181	0.018	***	-0.587	0.031	***	-0.634	0.039	***
Deposits	-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	***
Other_Banks_Lend_a	0.007	0.013		0.040	0.037							
Other_Banks_Borrow_a	0.015	0.096		0.021	0.096							
Other_Banks_Lend_abc							-0.018	0.016		-0.002	0.023	
Other_Banks_Borrow_abc							0.025	0.018		0.030	0.025	
Other_Banks_Liquidity	-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 Q2			2007 Q3: 2010 Q4			2002 Q1: 2007 Q2			2007 Q3: 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 – 2007Q2) and crisis period (2007Q3 – 2010Q4). Interbank market activity is measured in *Sum_Interbank_a* as the sum of the absolute value of the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Sum_Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list 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 bank

	Sum_Interbank_a						Sum_Interbank_abc					
	High Activity (>50°) (1)			Low Activity (<50°) (2)			High Activity (>50°) (3)			Low Activity (<50°) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.168	0.046	***	-0.022	0.004	***	-0.324	0.068	***	-0.117	0.023	***
DepositsFED	-0.207	0.064	***	-0.019	0.006	***	-0.777	0.049	***	-0.391	0.026	***
RWA	-0.021	0.017		0.003	0.004	*	-0.013	0.029		-0.025	0.011	**
Liquidity	-0.231	0.026	***	-0.029	0.003	***	-0.526	0.039	***	-0.255	0.025	***
Loans	-0.230	0.031	***	-0.025	0.004	***	-0.618	0.032	***	-0.264	0.024	***
Deposits	-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	**
Other_Banks_Lend_a	0.089	0.077		0.001	0.005							
Other_Banks_Borrow_a	0.188	0.173		0.028	0.036							
Other_Banks_Lend_abc							-0.024	0.026		0.009	0.008	
Other_Banks_Borrow_abc							0.067	0.038	*	-0.009	0.011	
Other_Banks_Liquidity	-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 *Sum_Interbank_a* as the sum of the absolute value of unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Sum_Interbank_abc* adds the Repo and Fed Fund positions to *Sum_Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list 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_Interbank_a						Sum_Interbank_abc					
	High Activity (>75°) (1)			Low Activity (<25°) (2)			High Activity (>75°) (3)			Low Activity (<25°) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.271	0.067	***	-0.006	0.003	**	-0.358	0.090	***	-0.078	0.021	***
DepositsFED	-0.302	0.082	***	-0.003	0.004		-0.797	0.064	***	-0.288	0.032	***
RWA	-0.012	0.021		0.000	0.002		0.010	0.041		-0.028	0.014	**
Liquidity	-0.336	0.040	***	-0.008	0.002	***	-0.598	0.046	***	-0.186	0.030	***
Loans	-0.335	0.041	***	-0.006	0.002	***	-0.699	0.041	***	-0.192	0.031	***
Deposits	-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	
Other_Banks_Lend_a	0.239	0.150		0.004	0.003							
Other_Banks_Borrow_a	0.331	0.297		0.046	0.025	*						
Other_Banks_Lend_abc							-0.054	0.042		0.012	0.009	
Other_Banks_Borrow_abc							0.120	0.066	*	-0.001	0.012	
Other_Banks_Liquidity	-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	***

	(1)	(2)	(3)	(4)
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 *Sum_Interbank_a* as the sum of the absolute value of the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Sum_Interbank_abc* adds the Repo and Fed Fund positions to *Sum_Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regresion coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.