Liquidity Coinsurance and Bank Capital*

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Abstract

This paper analyzes how the liquidity coinsurance provided by interbank markets affects the incentives to raise bank capital. Following Gale (2004), bank capital is considered as a buffer to shield deposits from banks' liquidity shocks and then it represents an additional (costly) source of liquidity insurance. Hence, bank capital and interbank markets are to a certain extent substitutes, and we discuss the conditions under which a negative relationship exists between the level of bank capital and the level of participation in the interbank markets. Moreover, we argue that in order to smooth liquidity shocks banks tend to postpone dividend payments when the interbank market is unable to provide additional liquidity because of highly correlated shocks throughout the economy. As an implication of this mechanism the level of participation in interbank markets has a positive relationship with the level of dividend payouts, and a negative relationship with both changes in dividends and changes in bank capital. All these relationships find support in the data.

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1 Introduction

This paper analyzes how the liquidity coinsurance provided by interbank markets affects the incentives to raise bank capital. Most of the banking literature provides a theoretical justification for bank capital on two grounds. On the one hand, capital serves to curb incentives to take excessive risk by highly leveraged financial institutions. On the other hand, capital provides a cushion for a shortfall in asset values in the event of bankruptcy. (See, e.g., Kim and Santomero [19], Furlong and Keeley [14], Gennotte and Pyle [16], Rochet [21] and Besanko and Kanatas [5]).

Alternatively, Gale [15] argues that bank capital also has a risk-sharing function. He presents a model of capital as a buffer stock, in which the optimal capital structure improves risk-sharing between shareholders and depositors. Similarly to Gale [15], we focus on the risk-sharing role of bank capital. However, we closely analyze the effect of the participation in interbank markets in determining bank capital. The emphasis on the relationship between bank capital and participation in interbank market arises naturally given that, at least in principle, interbank markets reduce the scope for bank capital as a risk-sharing device.

We model a two-region economy, in which each region is populated by risk-adverse depositors and risk-neutral investors. While the former deposit their endowment in banks, the latter provide bank capital. Banks acting on behalf of depositors have two investment opportunities: a short-term liquid asset (storage technology) and a long-term illiquid asset. Each region has uncertain liquidity needs characterized by a regional liquidity shock. The existence of an interbank deposit market allows banks in different regions to coinsure when regional liquidity shocks are negatively correlated. However, interbank markets are of little help when liquidity shocks are positively correlated. Therefore, some residual aggregate uncertainty remains.

The presence of aggregate uncertainty gives a scope for the use of bank capital as a risk-sharing device. That is, some of the undiversifiable risk can be transferred (at a cost) to risk-neutral investors. In a world without aggregate uncertainty the interbank market would be sufficient to deal with idiosyncratic liquidity shocks and there would be no need for bank capital. It follows that a reduction in aggregate uncertainty should imply a reduction in bank capital as well. This is indeed the case for certain parameters values but, surprisingly, it is not a general property of the model. This is due to the fact that a reduction in aggregate uncertainty implies also a reallocation in the investment decisions of the banks. In particular, when aggregate uncertainty reduces banks have an incentive to reduce the investment in the liquid asset and, as in Castiglionesi et al. [6], this can cause a higher consumption volatility. Bank capital in this case is valuable since it helps in moderating such volatility. Given that higher aggregate uncertainty implies lower interbank market participation, the model predicts a negative relationship between interbank market participation and bank capital only insofar bank capital is increasing in aggregate uncertainty.

Furthermore, banks collect a capital buffer to transfer part of the aggregate uncertainty to the risk-neutral investors. In our model, this is achieved by paying a dividend which is contingent on aggregate liquidity needs. In particular, when aggregate liquidity needs are high throughout the economy, it is optimal to postpone dividend payments. Given that in this case the interbank market is unable to provide additional liquidity, at the same time that banks postpone dividends they also tend to have smaller positions vis-a-vis other banks. This mechanism should produce a positive relationship between dividend payments and participation in the interbank market, as measured for example by the magnitude of the interbank net position, which is possible to validate empirically.

The model also predicts a negative relationship between current and future dividends so that when interbank market participation is low, current dividends are also low but future dividends tend to be high. This means that there exists a negative relationship between interbank market participation and changes in dividend payments, i.e., dividends tend to increase over time when interbank participation is low.

Finally, dividend payments also affect the value of bank capital. Namely, the payment of current dividends tends to reduce capital, both for an accounting reason and, within this framework, also because it signals lower dividends in the future. The postponement of a dividend instead signals higher future payouts to shareholders, and the value of bank capital should increase as a consequence. Since dividends are paid (postponed) when the participation in the interbank market is high (low), the model also delivers the testable prediction of a negative relationship between changes in bank capital and participation in the interbank market.

In the second part of the paper we test the empirical implications of our theoretical model. The main variable we are interested in is bank participation in the interbank markets. Unfortunately, the interbank market is an over the counter market and the participation by banks in such market is not publicly available. A database that provides a proxy for the level of participation in this market is Bankscope that contains information on the amount a bank lends to and borrows from other banks. We select relatively large banks with total assets greater than $1 billions (book value) from the EU, UK and Japan for the period of 2005-08.

Our empirical approach consists of two steps. We first investigate the empirical relationship between the interbank market position and the level of bank capital. Beside bank capital, we also use other independent variables controlling for factors that could influence the exposure of a bank in the interbank market. We find a negative and significant relationship between interbank markets position and bank capital. In the second step, we use the fitted values of the first regression as independent variable and we find support for the theoretical predictions of our model. In particular, we find a negative and significant relationship between changes in bank capital and interbank position. Similarly we find a negative and significant relationship between changes in dividend and interbank market participation (but only when interbank market participation is not instrumented). Finally, we find a positive and significant relationship between the level of dividends and the interbank markets position.

Our paper is clearly related to both theoretical and empirical works in banking. On the theory side, the paper closer to our is the one by Gale [15]. Contrary to him, we do not focus on the regulatory aspect of bank capital instead we analyze the potential substitution effect between the liquidity insurance provided by interbank markets and the insurance provided by bank capital. Similarly to Allen and Gale [3] we model interbank market as a device to decentralize the social planner solution. However, we consider aggregate uncertainty perfectly anticipated by economic agents (following Castiglionesi et al. [6]).[1]

On the empirical side, our paper relates to two strands of the literature: the one on bank capital and the other on the interbank market. Flannery and Rangan [10] and Gropp and Heider [17] look at the determinants of banks' capital holding. Flannery and Rangan [10] argue that the main cause of capital build-up of large U.S. banks in the 1990s was increased

[1] There is an extensive literature on capital regulation. Among the recent contributions, Hellman, Murdock and Stiglitz [18] show the perverse effect of capital requirement regulation since it reduces gambling incentives by putting bank equity at risk, however, it also harms banks' franchise values thus encouraging gambling. Diamond and Rajan [9] 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 [2] analyze the role of market discipline as a rationale to hold bank capital.

market discipline due to legislative and regulatory changes resulting in the withdrawal of implicit government guarantees. Gropp and Heider [17] test the determinants of bank 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 determinant of banks' capital structure is unobserved 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 ([11], [12] and [13]) analyzes banks' screening and monitoring activity in the fed funds market, and the behavior of this market during Russia' sovereign default. Cocco et al. [7] look at the importance of relationships as an important determinant of banks' ability to access the Portuguese interbank market. In a recent contribution, Afonso et al. [1] examine the impact of the financial crisis of 2008, specifically the bankruptcy of Lehman Brothers, on the functioning of the federal funds market. It is argued that while banks became more restrictive in which counterparties they lent to, the financial crisis did not lead to a complete collapse of the fed funds market. The novelty of our approach is to look at the co-determination of banks' capital holding and their interbank market participation. To our knowledge this topic has not been explicitly addressed in the empirical literature.

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 by the presence of interbank markets. Section 5 characterizes further the efficient allocation and it analyzes how the participation in the interbank market affects, respectively, bank capital, changes in bank capital, dividends and changes in dividends. Section 6 presents the data we used to test the model's predictions and the results of our regressions. Sections 7 concludes. All the proofs are in the Appendix.

2 The Model

The basic model is similar to Gale [15], and provides a rationale for the use of bank capital based on risk sharing. Consider a three-date economy ($t = 0, 1, 2$) with a single good available at each date for both consumption and investment. There are two assets: a short-term or liquid asset which matures in one period with a return of one, and a long-term or illiquid asset which requires two periods to mature and delivers a return $R > 1$. The short asset represents a storage technology (one unit of the good invested at $t = 0, 1$ produces one unit at $t+1$), while the long asset captures long-term productive opportunities (one unit invested at $t = 0$ produces R units at $t = 2$, and nothing at $t = 1$). Clearly, the choice of a portfolio of assets reflects a trade-off between returns and liquidity.

There are two regions $i = A, B$ in the economy, and each region is populated by 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

$$\rho c_0 + c_1 + c_2,$$

where $c_t \geq 0$, and $\rho > R$.

The second group is given by a unitary mass of 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 [8], 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 $\lim_{c \to 0} u'(c) = \infty$.

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

The regional shock ω^i takes the two values ω_H and ω_L, with $\omega_H > \omega_L$, with equal probability 1/2. Therefore, the expected value of the regional shock is

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

The economy is characterized by four possible states of the world $S \in \mathcal{S} = \{HH, LH, HL, LL\}$. In states HH and LL the two regions are hit by identical shocks while in states LH and HL they are hit by different shocks. To allow for various degrees of correlation between regional shocks, we assume that the probability that the two regions are hit by different shocks is $p \in (0,1)$. A higher value of the parameter p implies a lower correlation between regional shocks and more scope for interregional risk sharing. A simple baseline case is when the regional shocks are independent and $p = 1/2$. Table 1 summarizes the probability distribution of the liquidity shocks.

Table 1: Regional liquidity shocks

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

Agents cannot trade directly with one another, but there is a banking sector in the economy which makes up for the missing markets. Banks within the same regions are perfectly homogeneous and they collectively behave as a representative bank whose activity develops as follows. At $t = 0$ the representative bank (or simply the bank) collects the initial endowment of the depositors and an amount $e \geq 0$ of resources from the investors. Therefore, the amount e will henceforth be referred to as bank capital. The bank invests an amount y in the short asset and an amount $1+e-y$ in the long asset; then, in period 1, after the aggregate shock S is publicly observed, the consumer reveals his preference shock to the bank and receives the consumption vector $\left(c_1^S, 0\right)$ if he is an early consumer and the consumption vector $\left(0, c_2^S\right)$ if he is a late consumer. Similarly, after the state S has been revealed, investors receive the consumption vector $(d_1^S, d_2^S) \geq 0$.[2] Therefore, a risk sharing contract, also called an allocation, offered by the bank is fully described by an array

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

As in Allen and Gale (2000) we use a spatial metaphor to capture the existence of different groups of banks with different liquidity needs. Each region could correspond to a

[2] 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 $\left\{d_t^S\right\}_{S \in \mathcal{S}; t=1,2}$.

specific bank, a geographical region, a specific banking sector, etc. For our purposes, the economy represents a set of banks connected through an interbank market (to be explicitly introduced in section 4) together with their depositors and investors. In this sense, the parameter p represents a measure of the deepness of the interbank market, as it gives the probability of finding a bank with different liquidity needs to, potentially, trade with. In what follows we are interested in studying the effects of the interbank market on the incentives to hold bank capital. Since our focus will be on an interbank market able to decentralize the first-best allocation, we start in the next section to characterize optimal risk sharing and we will introduce the interbank market in section 4.

3 Optimal Risk Sharing

In this section we abstract from the interbank market and consider the problem faced by a planner that chooses an allocation to maximize the sum of ex-ante expected utilities of depositors, maintaining investors at their reservation utility (i.e., the utility they can obtain by consuming their endowment at $t = 0$). The planner is unable to observe the preference shock of individual depositors but can observe regional liquidity shocks. Notice that aggregate liquidity needs in the economy are the same in states HL and LH, and it is therefore optimal for the planner to move resources from one region 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 $\mathcal{S}' = \{H, M, L\}$ with the understanding that $M = \{HL, LH\}$, $H = \{HH\}$ and $L = \{LL\}$. It will also be convenient to denote with $p(s)$ the probability of state $s \in \mathcal{S}'$, where $p(M) = p$, and $p(H) = p(L) = (1 - p)/2$. 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

$$\begin{aligned} \omega_s c_1^s + d_1^s &\leq y, && (1)\\ (1 - \omega_s)c_2^s + d_2^s &\leq (1 + e - y)R + y - \omega_s c_1^s - d_1^s, && (2)\\ \sum_{s\in\mathcal{S}'} p(s)(d_1^s + d_2^s) &\geq \rho e. && (3) \end{aligned}$$

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 needs in the economy. The third constraint guarantees that investors get at least their reservation utility.[3] The planner's problem is therefore to choose a feasible allocation to maximize

$$\sum_{s \in \mathcal{S}'} p(s) \left(\omega_s u(c_1^s) + (1 - \omega_s) u(c_2^s) \right). \tag{4}$$

Without loss of generality, we can assume that $d_1^s = 0$ for each s. In fact, if a feasible allocation has $d_1^s > 0$ for some s, the alternative allocation with the same values for y, e, and $\{c_t^s\}_{s \in \mathcal{S}'; t=1,2}$, but with dividend payments given by $\widehat{d}_1^s = 0$ and $\widehat{d}_2^s = d_2^s + d_1^s$ is still feasible and gives agents the same expected utility. For this reason, we henceforth use d^s to denote the second-period dividend in state s, with the understanding that the first-period dividend is zero.

Notice that in states H and L each region's consumption needs can be satisfied with the resources available within the region. For example both regions have in state H at $t = 1$ a demand for liquidity equal to $\omega_H c_1^H$ and, from (1) with $d_1^s = 0$, we see that the available amount of the short asset within each region is in fact enough to satisfy the regional demand (i.e., it is $y \geq \omega_H c_1^H$). 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 regions. For example, with no rollover in state M, the amount of liquid resources available at $t = 1$ in both regions is $\omega_M c_1^M$. However, one region has a fraction ω_H of early consumers so that its demand for liquidity is $\omega_H c_1^M$, which results in an excess demand of $(\omega_H - \omega_M) c_1^M$. At the same time, the other region has a fraction ω_L of early consumers so that its demand for liquidity is only $\omega_L c_1^M$, 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 and excess supply at $t = 1$. At $t = 2$, resources move in the opposite direction in state M to clear up the regional excess demand and excess supply, while in states H and L each region can satisfy its own demand with its own resources.

[3]Notice that we are not explicitly considering the incentive contraints $c_1^s \leq c_2^s$ that prevent late consumers from pretending to be early consumers. This omission is however immaterial as the solution to the planner's problem automaticaly satifies such incentives constraints. This means that the first-best allocation is also incentive efficient (see Proposition 1).

4 Interbank Deposit Market

Consider now the decentralized economy in which the representative bank in each region offers a risk-sharing contract to its depositors and investors. We would like to know whether optimal risk sharing can also be achieved in this case. In the decentralized economy an allocation can only be achieved if it is feasible within each region considered separately. The first-best consumption levels would not entail any feasibility problem in states H and L as, in this case, the regional demand for consumption can be entirely satisfied using internal resources.[4] However, in state M both at $t = 1$ and $t = 2$, one region has an excess demand for consumption while the other region 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 that the bank in a given region deposits the amount $\omega_H - \omega_M$ with the bank in the other region at the same conditions applied to individual depositors. This means that when the fraction of early consumers in region i is ω_H the corresponding bank will behave as an early consumer and will withdraw its deposit at $t = 1$. In this case the bank obtains nothing at $t = 2$, while at $t = 1$ it gets $(\omega_H - \omega_M)\, c_1^M$ if the fraction of early consumers in the other region 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 region i is ω_L, the corresponding bank will behave as a late consumer by holding its deposit until $t = 2$, when it will finally withdraw it. In this case the bank obtains zero at $t = 1$ while at $t = 2$ it gets $(\omega_H - \omega_M)\, c_2^M$ if the fraction of early consumers in the other region is ω_H (i.e., if the state is M), and $(\omega_H - \omega_M)\, c_2^L$ otherwise (i.e., if the state is L).

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

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

with the first-best level of investment in the long asset given by $1 + e - y$. Thereafter, at $t = 1$ in states H and L the two banks withdraw their deposits at the same time so that the net flow of funds between regions is zero at both $t = 1$ and $t = 2$. First-best consumption levels are feasible within each region in states H and L and will therefore remain so also in the presence of interbank deposits markets. In state M the two regions receive asymmetric liquidity shocks so that one region will withdraw its interbank deposit at $t = 1$ (the region with the high shock), while the other will withdraw at $t = 2$ (the region with the low shock). For concreteness, let A be the region with the high liquidity shock. In this case in both regions the amount of the short asset at $t = 1$ is $y \geq \omega_M c_1^M$ but region A needs $\omega_H c_1^M$ to cover its withdrawals at $t = 1$. The bank in region A redeems its interbank deposit at $t = 1$, receives the amount $(\omega_H - \omega_M)\, c_1^M$. Therefore it is able to satisfy its budget constraint:

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

The bank in region B faces withdrawals from both its depositors and from the bank in region A for a total amount of

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

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

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

Budget constraints are also satisfied at $t = 2$, and the case in which region B receives the high liquidity shock is similar. Let $m_1 = (\omega_H - \omega_M)\, c_1^M$ and $m_2 = (\omega_H - \omega_M)\, c_2^M$ denote the amount that banks can withdraw at $t = 1$ and at $t = 2$, respectively. Table 2 below summarizes the net flow of funds between banks, as well as their net interbank positions, denoted by π_t at time t, in different states of the world. A bank net position is positive when it is a net borrower (a debtor), and negative when it is a net lender (a creditor).[5] 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 in what follows.

[5] 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			
$\mathcal{S}$	$\mathcal{S}'$	$\text{flows}_{t=1}$	π_1	$\text{flows}_{t=2}$	π_2	$\text{flows}_{t=1}$	π_1	$\text{flows}_{t=2}$	π_2
HH	H	0	0	0	0	0	0	0	0
HL	M	m_1	m_1	$-m_2$	0	$-m_1$	$-m_1$	m_2	0
LH	M	$-m_1$	$-m_1$	m_2	0	m_1	m_1	$-m_2$	0
LL	L	0	0	0	0	0	0	0	0

5 First-Best Allocation

In this section we further characterize the first-best allocation and we study how both bank capital and interbank deposit markets play a role in achieving the optimal risk sharing. In a nutshell, interbank markets can only work when bank liquidity needs are uncorrelated, that is in state M, but are of little help when banks are hit by the same liquidity shock. The existence of aggregate uncertainty on bank liquidity needs (i.e., the possibility of liquidity shocks that cannot be diversified away through the interbank market) creates a scope for bank capital. In fact, by raising bank capital part of this undiversifiable risk can be transferred to the risk-neutral investors at a cost ρ. We have

Proposition 1 *Assume $p < 1$ and consider the first-best allocation. If $e > 0$, there are two possible cases:*

1) $d^H = 2\rho e/(1-p) > 0$ and $d^L = d^M = 0$. In this case we have

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

Moreover, $c_2^L = c_2^M = c_2^H$ is not possible and positive rollover can occur: (i) in states L and M, in which case $c_1^M = c_1^L = c_2^L = c_2^M$; (ii) only in state L, in which case $c_1^L = c_2^L$; or (iii) never.

2) $d^H > d^M > 0$ and $d^{LL} = 0$. In this case we have

$$c_1^H < c_1^M < c_1^L \leq c_2^L < c_2^M = c_2^H,$$

and positive rollover can only occur in state L, in which case $c_1^L = c_2^L$.

This result is proved in the appendix and clarifies that the uncertainty about aggregate liquidity needs 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 aggregate fraction of early consumers. The risk-neutral investors can bear the aggregate uncertainty more efficiently, and banks can partially transfer it to them by collecting part of their resources at $t = 0$, in the form of bank capital, in exchange for a stochastic dividend at $t = 2$. The optimal way of arranging this form of risk sharing is to never pay a dividend in the state in which the marginal utility of late consumers is higher, that is in state L. However, it can be optimal to pay a positive dividend both in states H and M in which case second period consumption is constant across such states. To have an intuition of why banks do not want to raise enough capital as to completely insure their depositors, notice that when $c_2^H = c_2^M = c_2^L$, the marginal value of insurance is zero. However, the marginal cost of capital is positive, as investors incur a marginal cost $\rho > R$ in deferring their consumption to period two (see Allen and Gale [4]). The following result provides a sufficient condition guaranteeing that only case 1) in Proposition 1 is possible.

Proposition 2 *Assume R close to one, then banks pay a dividend only in state H, that is, only case 1 in Proposition 1 is possible.*

The intuition is that, when R is sufficiently close to 1 there is rollover both in states L and M. This directly implies that case 2 in Proposition 1 cannot occur (since in that case rollover happens only in state L). To conclude this section notice that we cannot exclude that the first-best level of capital is zero. This trivial case emerges if ρ is too large and bank capital becomes too costly to be used for risk-sharing purposes. In what follows we therefore abstracts from this case.

5.1 Bank Capital

The optimal amount of bank capital clearly depends on the scope of the interbank market as measured by p. Let us use the notation $e(p)$ to make this relationship explicit. The parameter p can be interpreted in a variety of ways. (1) At the level of a single bank, p reflects the degree of connectedness to the overall interbank network; (2) At the country level, p is affected by the external position of the banking system; (3) at the level of the overall economy, it reflects the relative importance of regional (and diversifiable) shocks versus systemic shocks. Intuitively, if p increases, the interbank market can be used more often to smooth the liquidity shocks and, as a consequence, the incentive to raise bank capital should be smaller. This intuition is indeed correct when we consider the extreme case of $p = 1$. In this case an allocation can be simply thought of as an array $\{y, e, c_1^M, c_2^M, d^M\}$, as whatever happens in states H and L has zero probability and is therefore irrelevant. In this case, the optimal allocation has $e \geq 0$, $d^M \geq 0$ and solves

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

subject to

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

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

$$(R - \rho) u'(c_2^M) \leq 0, \tag{9}$$

with equality if $e > 0$. Clearly (9) can never be zero which means that in this case we necessarily have $e = 0$. Hence, with no aggregate uncertainty, the interbank market is sufficient to smooth away liquidity shocks, and there is no need for bank capital. By using a continuity argument it is also clear that 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 aggregate 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, not only for sufficiently high values. The example assumes $R = 1.8$, $\rho = 2$, $\omega_H = 0.6$, $\omega_L = 0.4$, and depositors have constant relative risk aversion $\gamma = 2$. From panel (a) we can see that bank capital over total asset is indeed decreasing for all values of p. Panel (b) shows that dividends are paid both in state H and M. Finally, panel (c) shows consumption volatility at $t = 2$ with (right scale) and without (left scale) bank capital. Notice that the use of bank capital reduces the volatility of second-period consumption by a factor of 2. In this example R is relatively high which implies that case 2 in Proposition 1 is possible (and indeed a dividend is paid also in state M).

[FIGURE 1]

The negative relationship between the level of bank capital and p is not a general property of the model though. Indeed, Castiglionesi et al., [6] show that under general conditions small increases in p can induce higher consumption volatility due to a reduction in the bank liquidity ratio. The same effect shows up in this case and can induce banks to increase their amount of bank capital when p increases, provided that it remains below some threshold. Figure 2 shows a numerical example with $R = 1.3$, $\rho = 1.4$, $\omega_H = 0.8$, $\omega_L = 0.2$, and in which depositors have constant relative risk aversion $\gamma = 2$. From panel (a) we can see that bank capital is indeed slightly increasing until about $p = 0.4$ and decreasing thereafter. Panel (b) shows that the liquidity ratio, defined as $y/(1+e)$, is everywhere decreasing in p, both when bank capital is optimally set to the levels shown in panel (a), and when it is forced to zero. Panel (c) shows that in this example a dividend is only paid in state H (the value of R is lower than in the previous example). Finally, panel (d) shows the second-period consumption volatility both with (right scale) and without (left scale) bank capital. Notice that in the absence of bank capital, the consumption volatility would increase with p, for values of p below some critical level which is about 0.75 in this example. However, if banks can raise capital, as long as p remains below 0.4 in this example, the optimal level of capital is increasing in p. Bank capital is used to smooth the increased volatility of second period consumption that would be brought about by the reduced liquidity ratio displayed in panel (b). Indeed, second period consumption volatility is everywhere decreasing in p when bank capital is allowed.

[FIGURE 2]

5.2 Bank Capital and Interbank Markets

The relationship between bank capital and p is intuitive but is not very appealing as a testable empirical prediction due to the unobservability of p. However, the value of p also affects the activity on the interbank market which is captured by π_1, the net interbank position at $t = 1$. We are mainly interested in measuring to what extent the interbank market is able to provide liquidity insurance. In this sense, it does not matter whether π_1 is positive or negative (i.e., whether a bank is a lender or a borrower), and we can take the quantity $E\,|\pi_1| = pm_1$, as a measure of interbank activity.[6] Intuitively, when p is large a bank tends to hold a small amount of capital, be more active on the interbank market and, as a consequence, its expected net interbank position, measured in absolute value, tends to be larger. The opposite happens for a low value of p. This relationship is straightforward if we compare the extreme cases of $p = 1$ and $p = 0$. With $p = 1$ bank capital is zero and the expected net interbank position is positive, while for $p = 0$ bank capital is positive and the expected net interbank position is zero. By a continuity argument, the same insight holds if we compare values of p close to one with values of p close to zero. Hence, at least in this extreme case, the model points toward a negative relationship between the level of bank capital and the absolute value of the interbank net position which will be tested in section 6.

Notice, however, that the model fails to deliver a general prediction because the level of bank capital can be increasing in p and, therefore, it can also positively correlate with the net interbank position. Moreover, other considerations (like moral hazard or signaling) might affect the relationship between bank capital and interbank participation in a sensitive and non trivial way. We clearly abstract from these factors in the model, focusing on the risk sharing role of bank capital, but they can of course be relevant in the data. The following section develops a further prediction of the model on the relationship between *changes* in bank capital and the net position on the interbank market.

5.3 Changes in Bank Capital and Interbank Markets

Bank capital can be thought of as the value to investors of (expected) future dividends, and it clearly corresponds to e at $t = 0$. However, after the observation of the state s at $t = 1$, the uncertainty about future dividends is completely resolved, and the value of bank capital equals the dividend to be paid at $t = 2$ in the observed state. In this sense, the state s determines the change in bank capital between $t = 0$ and $t = 1$, which will be denoted by ΔCap. Notice that the state s also determines banks net position on the interbank market (see Table 2).

Table 3 displays the net position on the interbank market at $t = 1$ in absolute value $|\pi_1|$ together with the value of the changes in bank capital ΔCap, both variables as a

[6] Notice that pm_1 represents an ex-ante measure (i.e., taken at $t = 0$) of interbank activity. Notice also that $E\pi_1$ cannot even be considered as an alternative measure. In fact, from table 2 we have $E\pi_1 = p/2(m_1 - m_1) = 0$.

function of the state. Since the net position on the interbank market is in absolute value, the distinction between region A and B is immaterial.

Table 3: Change in bank capital and net interbank position

State	$Cap_{t=0}$	$Cap_{t=1}$	ΔCap	$\lvert\pi_1\rvert$
H	e	d^H	$d^H - e$	0
M	e	d^M	$d^M - e$	m_1
L	e	0	$-e$	0

We are interested in whether the change in bank capital is larger or smaller when banks participate in the interbank market, that is, we look at the sign of

$$\begin{aligned}\psi &\equiv E\left[\Delta Cap \mid \lvert\pi_1\rvert = m_1\right] - E\left[\Delta Cap \mid \lvert\pi_1\rvert = 0\right] \\ &= d^M - d^H/2.\end{aligned}$$

From Proposition 1 we know that $d^H > d^M$ but this is not sufficient to guarantee that $\psi < 0$. A sufficient condition for this is simply that R is close to one, as this ensures that $d^M = 0$ and therefore $\psi < 0$. Hence, when R is close to one, there surely is a negative relationship between changes in bank capital and interbank participation. With R large, the ambiguity emerges because in state L the value of capital also drops and the net interbank position is zero. Notice that, conditional on the state being different from M, we are assuming that both L and H have probability 1/2. More generally we might have $\Pr\{s = H \mid s \neq M\} = q$ and $\Pr\{s = L \mid s \neq M\} = 1 - q$, and we would therefore obtain

$$\psi = d^M - qd^H.$$

A result similar to Proposition 1 holds also in this more general case and, in particular, we still have $d^H > d^M$.[7] A negative sign for ψ would therefore obtain more generally for a

[7] More precisely, with $\Pr\{s = H \mid s \neq M\} = q$, proposition 1 holds more generally with $d^H = \rho e/q(1-p)$ in case 1). The entire analysis still holds in the more general case, with the caveat that when $q \neq 1/2$ the uncertainty on aggregate liquidity needs decreases in p only beyond some threshold. For example with $q = 1$, aggregate uncertainty (as measured for example by the variance of the aggregate liquidity shocks described in table 1) is clearly absent when $p = 0$ (the only possible state is HH in this case). Hence, when p increases, so does aggregate uncertainty till it eventually reaches a maximum, and decreases thereafter.

sufficiently large value of q. Hence, an alternative sufficient condition for $\psi < 0$ is that q is sufficiently large, as in this case the probability of the state L is small, and its impact is negligible.

5.3.1 Dividend Payouts and Interbank Markets

A general insight presented in this paper is that if bank capital is used for risk-sharing purposes, dividends should not be paid in states of the world where the marginal utility of depositors is high. This insight implies that allowing for early dividend payouts (i.e., dividends paid at $t = 1$), we should not expect to observe an early dividend in state H. In fact, because of low consumption levels, the marginal utility of early consumers is high in this case, and subtracting further resources to pay an early dividend would have a large cost. However, we could possibly observe early dividends paid in states L and M. A simple way of making dividends appealing also at $t = 1$ is to assume that investors prefer to consume at $t = 1$ than at $t = 2$. Formally, assume that the utility of the risk neutral investors is given by

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

with $\rho_0 > R > \rho_1 > 1$.[8]

An interesting case is with $q = 1$, that is state L is irrelevant, an early dividend paid in state M, but not in H, and a late dividend paid in H, but not in M. This is what happens in the numerical example shown in Figure 3, which assumes $\rho_0 = 2$ and $\rho_1 = 1.75$. Other parameters are as in the example of Figure 1, that is, $R = 1.8$, $\rho = 2$, $\omega_H = 0.6$, $\omega_L = 0.4$, and depositors have constant relative risk aversion $\gamma = 2$. The example only considers $p > 0.5$, as with $q = 1$ the variance of the aggregate liquidity shocks is maximum for $p = 0.5$ and decreases thereafter. Accordingly, panel (a) shows that bank capital is decreasing in p over this range. Panel (b) in Figure 3 shows that for p not too large (roughly below 0.68) a positive dividend is paid at $t = 1$ in state M. Panel (c) in the same Figure shows that a positive dividend is paid at $t = 2$ in state H. No further dividend is paid.

[FIGURE 3]

[8] That is, with respect to $t = 0$, consumption at $t = 2$ is discounted by the factor $1/\rho_0$, while consumption at $t = 1$ is only discounted by the factor $\rho_1/\rho_0 > 1/\rho_0$.

Table 4 summarizes the characteristics of the dividend stream in the example of Figure 3, and it relates dividend payouts to the position on the interbank market. Two predictions emerge: The net position in the interbank market at $t = 1$, can have (1) a positive relationship with the dividend paid at $t = 1$, and (2) a negative relationship with the change in dividends between $t = 2$ and $t = 1$.

Table 4: Dividends and net interbank position

State	$Div_{t=1}$	$Div_{t=2}$	ΔDiv	$\|\pi_1\|$
H	0	$d^H > 0$	$d^H > 0$	0
M	$d^M > 0$	0	$-d^M < 0$	m_1

Figure 3 also shows that the prediction of a negative relationship between changes in bank capital and participation in the interbank market is robust to the payments of early dividends. In fact, with no early dividends, the change in bank capital described in table 3 is entirely driven by an information effect. Now, a dividend paid at $t = 1$ has the effect of reducing the value of capital, in this case for an accounting rather than an information effect. Hence, in the example of Figure 3, the change in bank capital is larger in H, when market participation is low, than in M, when market participation is high.

To conclude, the insight that can be derived if we think of bank capital as a way to insure risk-averse depositors against their liquidity shocks, is that because interbank markets play a similar role, we should expect the participation in such markets to act as a substitute for the use of bank capital. Hence, the level of participation to the interbank market (as measured for example by the absolute value of the interbank net position) should have a negative relationship with (1) the level of bank capital, and (2) the changes in bank capital (driven by both accounting based or information based effects). Moreover, the participation in the interbank market should correlate (1) positively with the level of dividend payouts, and (2) negatively with the change in dividends. With these predictions at hand we now turn to the empirical section.

6 Empirical Analysis

6.1 Data

The interbank market is an Over the Counter market and its volume is not publicly available. The only public information about this market refers to the interbank borrowing and lending rates that are collected by central banks from different samples of banks and for different currencies.[9] In particular, this market refers to the borrowing and lending of unsecured funds among banks in the London wholesale money market.

A database that provides a proxy for the volume in this market is Bankscope. Bankscope contains information on the amounts a bank lends to, and borrows from other banks. This information comes from banks balance-sheet and has a yearly frequency. This means that it does not allow to observe all the interbank flows throughout the year, nor it allows to distinguish interbank loans of different maturities, or the positions toward different banks. Nonetheless it gives a picture of the overall position a bank has vis-a-vis other banks at the time of the balance-sheet closure, that we take as a proxy of the interbank participation during the year.

We select banks with total assets greater than \$1 billions (book value) from the EU, UK, and Japan for the period of 2005-2008.[10] US banks are not part of the sample because Bankscope contains very limited information on their interbank market exposure. Most US banks participate in the Fed-Funds money market, which is characterized by uncollateralized loans of reserve balances at the Federal Reserve banks. US banks and other depository institutions keep reserves at the Federal Reserve banks to meet reserve requirements and to clear financial transactions. Institutions with excess reserves lend to institutions with reserves deficiencies. Although the characteristics of this market are similar to those of the London interbank market, because of data availability we choose to concentrate our analysis only on European and Japanese banks.

Our model relates interbank market participation to bank capital. In order to measure the exposure to the interbank market we take the difference of what a given bank lends

[9] For US LIBOR the sample of banks is: Bank of America, Bank of Tokyo-Mitsubishi UFJ Ltd, Barclays Bank plc, Citibank NA, Credit Suisse, Deutsche Bank AG, HBOS, HSBC, JP Morgan Chase, Lloyds TSB Bank plc, Rabobank, Royal Bank of Canada, The Norinchukin Bank, The Royal Bank of Scotland Group, UBS AG, West LB AG. For the Euribor the panel is larger: 39 banks from Europe and 4 international banks: Bank of Tokyo – Mitsubishi, J.P. Morgan Chase & Co., Citibank, UBS (Luxembourg) S.A.

[10] We perform robustness checks for all our subsequent regressions in which we include data only until August 2008 to see whether some of our results are driven by the Lehman effect. We do not find evidence of this.

and borrows from other banks. We use the absolute value of this difference, normalized by total assets, as a measure of liquidity risk sharing provided by the interbank market. We are rather interested in a bank's exposure to the interbank market than in the question of whether a bank is a net lender or borrower.

We use a broad definition of bank capital that includes equity and reserves as well as subordinated debt and hybrid capital. Our model does not capture all the peculiarities and the different roles that bank capital may have. Instead, it focuses on its role as a buffer against liquidity shocks. For this reason any source of funding with a long maturity and no collateral could be considered a good proxy for the capital variable included in our model. We consider book value and not market value of bank capital because in our framework capital plays a liquidity buffer role. In contrast, market capital is a forward looking measure related to future profitability and market condition rather than simply a liquidity buffer.

We exclude from the sample the banks that do not report interbank market information or total capital. Besides the variables of main interest, we also include a series of balance-sheets variables as control variables such as the amount of loan outstanding, the amount of deposits, loan losses provisions as well as the return on asset, return on equity, and bank assets.

We also include as control variables three proxies of bank liquidity. For each bank we calculate the total amount lent in the interbank market by the other banks in the *same* country and normalize this number by the total asset of these banks. We repeat the same calculation for the amount borrowed and for the liquid assets these banks hold. These variables attempt to capture the potential size of the interbank market and the amount of liquidity banks decide to hold rather than tender in the interbank market.

In our theoretical section we also derive predictions about dividend payments and changes in dividend payment from one year to the other. The variable we consider for dividends is the dividend payout. In our dataset we have excluded all banks that do not report bank capital or position in the interbank market. However, even in this restricted sample the variable dividend payout does show a large number of missing values. However, a missing value is likely to indicate that no dividend was paid if a value for earnings was reported. For this reason, in the case we substitute the missing value with zero.

We report descriptive statistics of the sample of banks we considered, i.e., those banks that report both their position in the interbank market and the level of total capital.

Table 5 provides descriptive statistics for the variables we use. The mean total book assets is US$77,89 billion and the median is US$5,94 billion. The sample exhibits considerable heterogeneity in the cross-section. The banks' interbank position (measured by the absolute value of the difference of their lent and borrowed amount) is on average 9.66 percent of total assets with a median of 4.72 percent, but the dispersion is rather significant. The same applies to bank capital. On average bank capital is equal to 9.02 percent of total assets but the standard deviation is 9.48 percent. Deposits and loans are on average 60.92 percent and 64.85 percent of total assets, respectively. The return on equity is about 7.33 percent and the dividend payout ratio (conditional on being not zero) is 38.13 percent. However, there is a large variability in the dividend payout ratio (also through time, see changes in dividend payout). The three proxy variables we use for measuring the potential size of the interbank market and liquidity available present a mean that ranges from 12.60 percent to 15,31 percent over total assets, with a significant variability among banks.

[TABLE 5]

The sample exhibits considerable heterogeneity in the time series as well as in the cross-section as Tables 6 and 7 show. In Table 6 we report the averages of all the considered variables for each year of our sample period. The highest participation in the interbank market is in 2006. In that year the average interbank position of the banks in our sample is 10.44 percent of total assets. In 2007 we observe a small reduction of 0.16 percent and in 2008 a greater reduction of 3.23 percent.

The composition of banks balance-sheets also shows changes over time. Capital and profit measures almost always decrease throughout the sample period. At the same time, we observe an increase in the amount of deposits held by banks in 2008. Loans over total assets remain fairly stable.

[TABLE 6]

Our sample displays variations also at the cross-sectional level indicating heterogeneity among banks. This feature is highlighted in Table 7 where we report the averages of all variables across banks with different assets size. We define four categories according to the size of total assets: from US$1 to US$20 billion (small), from US$20 to US$100 billion (medium), from US$100 to US$200 billion (large) and above US$200 billion (extra-large).

Table 7 illustrates how the average participation in the interbank market differs across banks with different assets size. Small and medium banks have on average an interbank position of about 10 percent over total assets, while the larger banks this figure is about 8 percent. The composition of the balance sheet also seems to be rather different among the four categories. Small banks have a large part of their total assets invested in loans, hold larger loan-loss reserves, a larger amount of capital as well as a larger amount of deposits.

[TABLE 7]

Table 8 reports the pair-wise correlation between all the variables we consider. Correlations among the explanatory variables and control variables are not large, therefore we do not have to worry about collinearity in the analysis we perform.

[TABLE 8]

6.2 Results

The theoretical model presented in the previous section provides three testable implications. First, banks choose to hold a higher level of capital if they expect to participate little in the interbank market. Second, banks delay paying dividends to shareholders when the interbank market is less able to provide liquidity insurance as a consequence of banks facing common shocks. Hence, both changes in bank capital and changes in dividends should be negatively related to participation in the interbank market. Third, the level of dividend paid should be positively related to interbank market participation.

6.2.1 First panel analysis: Interbank Markets

We start by investigating the empirical relationship between a bank's interbank market position and its level of capital. There could be many factors affecting the exposure of a bank in the interbank market. We are not able to directly measure neither the demand nor the supply of funds. However, we try to control for variables that, by affecting either the demand or the supply side, influence the observed interbank market position. On the demand side, a larger loan portfolio may result in a larger need to borrow in the interbank market, while a larger deposit base reduces the need to participate in the interbank market. On the supply side, a larger loan portfolio may render the borrower more risky, hence it may result in lower supply of funds. Higher loan loss provisions over loans (or over net income) may reflect an higher risk of the portfolio of the bank but at the same time it indicates that more reserves are allocated to cover future losses. Accordingly, this has in principle an ambiguous effect on interbank participation. On the contrary, return on asset represents the profitability of the bank and therefore the ability of the bank to pay back its debt. The need and the role a bank may have in the interbank market could be also related to the size of the bank. For this reason we control for this effect. The Hypothesis that we are testing is the following:

Hypothesis 1: Banks capital holding is negatively related to their interbank market participation

In order to test this hypothesis, we check whether banks holding a large amount of capital and liquidity have less exposure in the interbank market. In the model specification, interbank market participation is regressed on two sets of fixed effects (countries, years) and on the lagged value of bank capital and of lagged liquidity. As a measure of interbank market participation, we use the absolute value of the difference between the amount lent and borrowed from other banks over total bank assets. We include a lagged measure of banks liquidity holdings (normalized by total assets) which comprise cash and government securities. The OLS regression performed is:

$$Y_{i,j,t} = \alpha + a_j D_{i,j} + a_t D_{i,t} + b_1 CAP_{i,j,t-1} + b_2 LIQ_{i,j,t-1} + \underline{cX} + \epsilon_{i,j,t}, \qquad (10)$$

where $Y_{i,j,t}$ is the dependent variable that represents the interbank position of bank i belonging to country j at time t, the D's denote the dummy variables, α is the constant, a_j, a_t, b_1 and b_2 are coefficients, $\underline{c}$ is a vector of coefficients and $\epsilon_{i,j,t}$ is the error term. $\underline{X}$ is a set of control variables that include loans over total assets, deposits over total assets, loan loss provisions over loans, return on assets, and bank size. We also include yearly and country dummy variables and our market liquidity proxies. In line with equation (10), we perform a robust standard error panel regression and the results are reported in Table 9.

[TABLE 9]

Column 1 in Table 9 reports that the *lagged value of bank capital* is negative and statistically significant in explaining interbank market participation. This suggests that there is a strong substitution effect between bank capital and interbank market participation. The same applies to *lagged value of liquidity*. Again the coefficient is negative and statistically significant showing that lagged value of liquidity is negatively related to the interbank position. This indicates that banks that hold a large amount of liquidity in terms of securities, that could be used as collateral at the Central Banks or easily sold in the market, participate less in the interbank market. Two out of the three variables we use as proxies for the interbank market liquidity are significant. The variable capturing the total amount due to banks has a positive sign. This indicates that when in the country the amount lent in the interbank market is large, the participation in the interbank market by each single bank is larger. The variable that proxy the level of liquidity holding by the other banks in the country is also significant (in this case at 1% level) but with a negative sign. This indicates that when the other banks retain more liquidity the participation in the interbank market reduces.

Besides the main variables of interest, some of the control variables are also significant. Loans over total assets is significant and with a negative sign, indicating that more risky banks participate less in the interbank market. Loan loss provision over loans is also significant but with a positive sign indicating that banks that allocate more reserves to loan losses are considered safer and participate more in the interbank market. The coefficient of the return on asset is also significant with a positive sign, meaning that more profitable banks participate with a larger position in the interbank market. The size variable is also significant with a negative size. This result could be explained by the fact that large banks mostly play the role of collecting money and distributing it rather than directly finding or providing insurance in the interbank market. Among the country dummies, only the one for Japan is significant indicating that, on average, the level of participation of the Japanese banks in the interbank market is lower than that of banks in other countries.

We also perform other regressions reported in Columns 2 and 3 of Table 9. In Column 2 we substitute the return on asset with the return on equity. The latter variable is not significant indicating that total profitability of the bank is more relevant than the remuneration of equity capital in determining the participation in the interbank market. In Column 3 we substitute loan loss provision over total loans with loan loss provision over net income. This is because the former variable could be affected by loan portfolio size that is also a variable relevant for interbank participation. Even in this case the coefficient is significant with a positive sign, indicating that the effect is driven by loans loss provision. In an unreported regression, we also include both variables and in this case the variable that remain significant is loan loss provision over total loans (results are provided upon request). Overall, the main results is that considering different specification of the control variables the significance of lagged capital and lagged liquidity remain the same.

6.2.2 Second panel analysis: Changes in Bank Capital and Dividends

The second prediction of our theoretical model is that changes in bank capital are influenced by the level of participation in the interbank market. In our setup the change in bank capital is a result of a change in expectation over future dividends upon the realization of the state. Hence, a similar relationship to changes in bank capital can be obtained between changes in dividend and interbank market participation. Notice that in our analysis we used a broad definition of bank capital that includes also hybrid capital and subordinated debt. The theoretical model introduced in section 2 does not distinguish between these different sources of bank capital, but clearly refers to a broad notion of capital as a liquidity buffer. The consequence is that what we call *dividend payments* in the theory section indeed refers to the remuneration of all of the different sources of bank capital. Unfortunately, we do not have data on the remuneration of hybrid capital or subordinated debt, but we expect them to vary less than cash disbursements to equity holders. For this reason, in the following regressions we use dividends in the standard sense of cash distribution to equity holders, and we divide them by the net income for normalization (which we call the dividend payout).

Our model suggests that when the interbank market is unable to provide coinsurance because of highly correlated liquidity shocks, the marginal utility of capital becomes high. As a consequence, no dividend is paid in this state of the world, and compensation for holding bank capital is postponed in the form of higher future dividends. On the contrary, in states of the world when the interbank market works well, i.e., it is able to provide coinsurance against liquidity shocks, the marginal value of capital is relatively low. Shareholders can immediately be rewarded with a dividend payment, and will therefore receive smaller payouts in the future. Hence, the difference between current and future dividends should be less pronounced, or even turn negative.

As for bank capital, the model suggests that its value should increase when the interbank market does not work well, and should instead decrease (or increase by a smaller amount) when the interbank market is able to provide coinsurance. Hence, the relationship between interbank market participation and changes in bank capital is predicted to be negative. More specifically we test the following hypothesis:

Hypothesis 2: Bank capital changes and dividend changes are both negatively related to the interbank market participation.

The prediction for the relationship between the level of bank capital and interbank market participation is hard empirically to investigate because many factors can lead to a change in the level of capital, and some of these variables could also affect the decision to participate to the interbank market. Therefore, we cannot perform a simple panel regression as presented in equation (10) where we analyze the relationship between lagged bank capital and the interbank position because of potential endogeneity issues. In order to address this problem we employ the two-stage least squares method. More formally, we model the bank's interbank position in reduced form equation:

$$Y_{i,j,t} = \alpha + a_j D_{i,j} + a_t D_{i,t} + b_1 CAP_{i,j,t-1} + b_2 LIQ_{i,j,t-1} + \underline{c_1 X_1} + \underline{c_2 X_2} + \epsilon_{i,j,t} \tag{11}$$

and the change of bank capital as:

$$\Delta CAP_{i,j,t} = \alpha + a_j D_{i,j} + a_t D_{i,t} + b_1 CAP_{i,j,t-1} + b_2 LIQ_{i,j,t-1} + \underline{c_1} X_1 + \eta_{i,j,t}, \tag{12}$$

where $\underline{X_1}$ and $\underline{X_2}$ are two sets of exogenous variables and $\epsilon_{i,j,t}$ and $\eta_{i,j,t}$ are the error terms. We use the exogenous variables $\underline{X_2}$ only in equations (11), where they serve as instruments for the interbank position variable. The endogeneity in the model can arise from potential correlations of interbank market participation and the error term $\eta_{i,j,t}$ in equation (12). We perform several tests (Kleibergen-Paap and Hansen tests) in order to test the goodness of the instruments used.

In our regression we include variables that may affect the bank incentives to alter its capital besides interbank market participation (i.e., changes in loans, loan loss provisions over loans and return on assets, banks size). The explanatory variables that we include in $\underline{X_2}$ as instrumental variables for interbank market participation are the three proxies for the interbank market size and liquidity. These variables are not directly related to changes in bank capital (they are in fact related to balance-sheet information of other banks), but do affect the interbank market position of the bank. For this reason they are potentially good instruments. The first-stage OLS estimates are reported in Table 9.

Table 10 report the second-stage estimates and it shows that the correlation between change in bank capital and interbank market position is in line with our theoretical prediction. Indeed, Column 1 in Table 10 displays that the change in bank capital is negatively related to the instrumented values of bank participation in the interbank market and it has statistical significance. The tests for endogeneity confirms that the instruments we used are exogenous: the Kleibergen-Paap test for weak instruments rejects the null hypothesis that the instruments are underidentified and the Hansen test fails to reject the null hypothesis of endogeneity in the interbank market variable. Hence, the coefficient estimates are both consistent and efficient.

[TABLE 10]

Some of the control variables included in the regression are also significant. The change in total loans variable has a positive sign. Hence, banks adjust their capital in line with their loan position (and according with capital requirements). However, our result shows also that banks do change their capital depending on their participation to the interbank market. The other variable that is also significant with a negative sign is lagged capital. This result indicates that the higher the bank capital the lower is the change of bank capital. Bank size is also significant with a negative sign indicating that larger banks change less their capital (or reduce their capital by a larger amount) than small banks. Yearly dummy variables are both significant, indicating that capital increased more between 2006 and 2007 than between 2007 and 2008. Country dummies indicate that Japanese banks on average increased less their capital during the sample period.

Columns 2 and 3 in Table 10 consider a couple of robustness checks. In column 2 we run a step-wise regression (i.e., we eliminate the insignificant regressors starting with the less significant one). In column 3 we use return on asset instead of return on equity among the control variables. Contrary to return on equity, the profitability of the bank do affect positively the change in bank capital. In both cases the negative relationship between interbank participation and change in bank capital is not affected.

To consider the relationship between dividends and interbank market participation we cannot run similar regressions as in Table 10 because the dependent variable in many cases assumes a value of zero. In this case the OLS regression will be biased. Therefore, to investigate the relationship between dividends and interbank market participation, we use a Tobit regression. The Tobit regression allows to account for the censored variable to be zero. The specification of the model is as follows: $m_{i,j,t}$ is an observable variable which depends on a latent variable $m^*_{i,j,t}$. The relationship between the observable and latent variable is:

$$\begin{aligned} m_{i,j,t} &= m^*_{i,j,t} \ \text{ if } m^*_{i,j,t} > 0 \\ m_{i,j,t} &= 0 \ \text{ if } m^*_{i,j,t} \leqq 0 \end{aligned}$$

The latent variable linearly depends on a set of explanatory variables through a parameter that determines the relationship between the explanatory variables and the latent variable. More specifically:

$$m^*_{i,j,t} = a_j D_{i,j} + a_t D_{i,t} + b_1 CAP_{i,j,t-1} + b_2 LIQ_{i,j,t-1} + \underline{c_1} X_1 + \eta_{i,j,t}. \tag{13}$$

The Tobit regression allows to estimate the coefficients a_j, a_t, b_1, b_2, $\underline{c_1}$ from the observable variable $m_{i,j,t}$.

In our case the dependent variable is the change in dividend payouts. Column 1 in Table 11 reports the results, and it shows that also the change in dividend payouts is negatively related to the bank participation in the interbank market. Some of the control variables included in the regression are also significant. Lagged capital over total assets is significant and negative, indicating that the change in dividend payment is lower if the bank holds a large amount of capital. We find also a negative relationship for the loan loss provision over net income. On the other hand, changes in total loans present a positive relationship with changes in dividends. Furthermore, larger banks tend to change more their dividend payments. Yearly dummies are significant with a negative sign indicating that banks in 2006 and 2007 change less their dividend payment compared with the 2008. Country dummy variable of Japan is significant indicating that Japanese banks changes more their dividend payments. Column 2 in Table 11 displays the results of the step-wise regression. The negative relationship between changes in dividend and interbank market participation is confirmed.

However, if the variables that affect changes in dividends may also affect interbank market participation we should instrument again our variable of interbank market participation. Therefore, we perform a Tobit regression with instrumental variables. The interbank market participation is instrumented as before. Results are reported in Column 3 of Table 11. In this case the regression shows that the relationship between changes in dividend and interbank market participation is still negative but the coefficient is not significant. This result can be due to two factors: first, we have a limited number of observation for changes in dividends; second, the series presents a lot of zeros.

[TABLE 11]

6.2.3 Third panel analysis: Dividend Payouts and Interbank Markets

In the analysis performed above we show that change in bank capital has a negative relationship with the interbank market exposure. Bank capital may change due to many different forces, such as larger or lower dividend payment as well as bank recapitalization. More specifically the hypothesis tested is:

Hypothesis 3: Dividend payouts are positively related to the interbank market participation.

In the panel regression therefore we concentrate on dividend payment. We use again the two step Tobit panel regression where $m_{i,j,t}$ in this case is dividend payout. The aim is to look at the relationship between the absolute value of the interbank position and dividend payout. Results are shown in Table 12.

[TABLE 12]

Column 1 in Table 12 shows that dividend payouts are positively related to the instrumented values of bank participation in the interbank market. Therefore, as suggested by our model, if bank capital is used for risk-sharing purposes, banks should pay less dividends (banks should avoid to distribute income) when the participation in the interbank market is low. Some of the control variables included in the regression are also significant. Loans over total asset is significant and positive, the lagged level of capital is also relevant for dividend payment. Size is significant and positive indicating that dividend payment is larger for large banks. Yearly dummies are not significant. Country dummy variables are significant and positive. This means that Japan and UK on average pays a larger percentage of dividend over net income compared to other banks in the sample. However, the test on exogeneity based on the Wald test fails to reject the null hypothesis of endogeneity in the interbank market variable only at 5% level.

In Column 2 in Table 12 we perform a step-wise regression. Eliminating the insignificant regressors, the dividend payouts are still positively related to the instrumented values of bank participation in the interbank market. However, the inclusion of other instrumental variables reduces the significance of the Wald test in rejecting the hypothesis of endogeneity.

7 Conclusions

In this paper we analyzed a model of multiple banks to study how interbank market participation affects the incentives to hold bank capital for risk-sharing purposes. We discuss under which conditions a negative relationship exists between bank participation in the interbank market and bank capital. The model also predicts a negative relationship between changes in bank capital and interbank participation as well as changes in dividend and interbank market participation. Furthermore, we find a positive relationship between the level of dividends and interbank participation. We use Bankscope dataset to verify if the model's prediction were empirically validated, and we found support to (almost) all of them.

Appendix

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 corresponding dividend paid to investors at $t = 2$ is d. Formally, given (y, e, d, ω) with $y \in [0, 1+e]$, $\omega \in (0,1)$, $e \geq 0$ and $(1+e-y)R > d \geq 0$, we consider the value function

$$\begin{aligned} V(y,e,d,\omega) \equiv & \max_{c_1,c_2} \{\omega u(c_1) + (1-\omega) u(c_2) \\ & \text{s.t. } \omega c_1 \leq y \text{ and } (1-\omega)c_2 + d \leq (1+e-y)R + y - \omega c_1\}, \end{aligned} \tag{14}$$

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

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

$$V_1 = \partial V / \partial e = u'(C_1) - Ru'(C_2), \tag{15}$$

$$V_2 = \partial V / \partial e = Ru'(C_2), \tag{16}$$

$$V_3 = \partial V / \partial d = -u'(C_2). \tag{17}$$

The policies C_1 *and* C_2 *are given by*

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

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 $\xi = (y, e, d, \omega)$ and, respectively, $\xi' = (y', e', d', \omega)$, 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 (15) note that from the envelope theorem

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

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

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

which substituted in the previous expression give (15). Expressions (16) and (17) are obtained similarly. Considering separately the cases $\lambda > 0$ (no rollover) and $\lambda = 0$ (rollover), it is then possible to derive the optimal policies. ■

Lemma 2 $C_1 \leq C_2$ *for all* (y, e, d, ω)*. In particular given* $\widehat{y} = \omega(R(1+e) - d) / (1 - \omega + \omega R)$*, we distinguish two cases:*

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

$$\frac{y}{\omega} > C_1 = C_2 = y + R\left(1 + e - y\right) - d > \frac{\left(1 + e - y\right)R - d}{1 - \omega},$$

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

$$C_1 = \frac{y}{\omega} \leq y + R\left(1 + e - y\right) - d \leq \frac{\left(1 + e - y\right)R - d}{1 - \omega} = C_2,$$

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

Proof of Lemma2. The proof follows from inspection of C_1 and C_2 in Lemma 1. ■

Since $C_1 \leq C_2$ late consumers never have an incentive to mimic early consumers. Clearly, the opposite is also true so that, even if consumers have private information on their preference shocks, incentive compatibility is not an issue here. An immediate consequence of Lemma 2 is the following corollary.

Corollary 1 *If rollover is optimal in problem (14) for some (y, e, d, ω) then it is also optimal for any (y, e, d', ω') with $\omega' \leq \omega$ and $d' \geq d$.*

The first best allocation can be characterized in terms of the value function defined in (14). In particular, consider the following problem

$$\max_{y,e,\{d^S\}_{S\in\mathcal{S}'}} \sum_{s\in\mathcal{S}'} p(s)V(y, e, d^s, \omega_s) \tag{18}$$

subject to

$$\begin{aligned} \sum_{s\in\mathcal{S}'} p(s)d^s &\geq \rho e; & (19)\\ d^s &\geq 0;\ \ s = H, M, L & (20)\\ e &\geq 0. & (21) \end{aligned}$$

The solution to the above problem provides the first-best values of $y, e,$ and $\left\{d^S\right\}$, while first-best consumption levels are given by

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

Proof of Proposition 1. Assume $e > 0$, and let η and ϕ_s be the Lagrange multipliers for (19) and (20). Using Lemma 1 and noting that at the optimum $c_t^s = C_t(y, e, d^s, \omega_s)$, first order conditions are

$$\sum_{s\in\mathcal{S}'} p(s)u'(c_1^s) = R\sum_{s\in\mathcal{S}'} p(s)u'(c_2^s), \tag{22}$$

$$R\sum_{s\in\mathcal{S}'} p(s)u'(c_2^s) = \eta\rho, \tag{23}$$

$$u'\left(c_2^s\right) = \eta + \frac{1}{p(s)}\phi_s, \tag{24}$$

The proof is now organized in three steps.

Step 1 shows that we always have $d^H > 0$ and $d^L = 0$, while we can have either $d^M > 0$ or $d^M = 0$.

From (23) $\eta > 0$, so that $\sum_{s\in\mathcal{S}'} p(s)d^s = \rho e$. Since $e > 0$, d^s cannot be zero for all s. They cannot all be strictly positive either, otherwise from (24), with $\phi_s = 0$ for all s, we obtain

$$\sum_{s\in\mathcal{S}'} p(s)u'(c_2^s) = \eta$$

which is incompatible with (23) because $R < \rho$. Assuming $d^L > 0$ we are immediately led to a contradiction. In fact, (24) with $\phi_L = 0$ implies $c_2^L \geq c_2^s$ for both $s = M, H$. But we either have $d^M = 0$ or $d^H = 0$, and they are both incompatible with Lemma 1. In fact, if for example $d^M = 0$, since $\omega_L < \omega_M$, Lemma 1 implies

$$\begin{aligned} c_2^L &= \max\left\{\frac{(1+e-y)\,R - d^L}{1-\omega_L}, y + R\,(1+e-y) - d^L\right\} \\ &< \max\left\{\frac{(1+e-y)\,R}{1-\omega_M}, y + R\,(1+e-y)\right\} = c_2^M. \end{aligned}$$

Assuming $d^H = 0$ we obtain a similar contradiction. For a similar reason it is impossible that $d^M > 0$ and $d^H = 0$. Therefore we only have two possible cases: 1) $d^H = 2\rho e/(1-p) > 0$ and $d^M = d^L = 0$, and 2) $d^H > 0$, $d^M > 0$, and $d^L = 0$. In both cases plugging (24) with $\phi_H = 0$ into (23) we obtain

$$R\sum_{s\in\mathcal{S}'} p(s)u'(c_2^s) = \rho u'(c_2^H) \tag{25}$$

which together with (22) characterize the optimal values of y and e.

Step 2 establishes that positive rollover is possible in state s only if $d^s = 0$.

Assume by contradiction that in state s we both have positive rollover and $d^s > 0$. From (24) with $\phi_s = 0$ we have

$$c_2^L \leq c_2^s. \tag{26}$$

Now, with positive rollover in state s (i.e., $\omega_s c_1^s < y$) we also have $c_2^s = c_1^s$, and since $c_1^L \leq c_2^L$, (26) implies $c_1^L \leq c_1^s$ which, given that $\omega_L \leq \omega_s$, in turn implies

$$\omega_L c_1^L \leq \omega_s c_1^s < y,$$

that is, we must also have positive rollover in state L. Hence, $c_1^L = c_2^L$ and from Lemma 1 we obtain

$$\begin{aligned} c_2^L &= y + (1 + e - y)R \\ &> y + (1 + e - y)R - d^s = c_2^s \end{aligned}$$

which contradicts (26). Hence, positive rollover is possible only in states where no dividend is paid. Given this result it is possible to see that if $d^H > 0$ and $d^M > 0$ we also have $d^H > d^M$. To this end, just notice that there cannot be rollover in this case in states H and M. Moreover, (24) with $\phi_H = \phi_M = 0$ implies $c_2^H = c_2^M$, and we therefore have

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

which together with $\omega_H > \omega_M$ in turn implies $d^H > d^M$.

Step 3 shows how consumption levels are ordered in cases 1) and 2) of the proposition. Notice that we can never have

$$c_2^H = c_2^M = c_2^L$$

as, given (24), this can only happen if $\phi_H = \phi_M = \phi_L = 0$, which is in turn incompatible with (23).

In case 1), i.e., $d^H > 0$ and $d^M = d^L = 0$, there are three possible sub-cases:

(i) Rollover in both states M and L. Therefore we have

$$c_1^M = c_2^M = c_1^L = c_2^L = y + (1 + e - y)R,$$

and, (24) with $\phi_H = 0$, together with Lemma 2 imply

$$\begin{aligned} c_2^H &> y + (1 + e - y)R > y + (1 + e - y)R - d^H \\ &> \frac{y}{\omega_H} = c_1^H. \end{aligned}$$

(ii) Rollover only in state L. From Lemma 2 we have

$$c_1^M = \frac{y}{w_M} \leq y + (1+e-y)R \leq \frac{(1+e-y)R}{(1-w_M)} = c_2^M,$$

and since $\omega_H > \omega_M > \omega_L$, given Lemma 2 and (24) we obtain

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

(iii) No rollover in any state. From Lemma 2 and $\omega_H > \omega_M > \omega_L$ we immediately have

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

In case 2), i.e., $d^H > d^M > 0$, and $d^L = 0$, there are two sub-cases, (i) rollover in state L and (ii) no rollover in any state, and they follow a similar logic as in sub-cases (ii) and (iii) of case 1) but now we clearly have $c_2^M = c_2^H$.

Steps 1 to 3 taken together complete the proof. ■

Proof of Proposition 2. Consider the limiting case with $R = 1$. It is possible to check that the solution to the planner's problem described in section 3 involves $y \geq w_H$, $e = d^s = 0$, $c_t^s = 1$, for $s = H, M, L$, and $t = 1, 2$. Intuitively, in this case the short asset clearly dominates the long asset, and the tradeoff between returns and liquidity vanishes. The best that a risk-averse agent can obtain is to consume its unitary endowment at $t = 1$ if he turns out to be an early consumer, or at $t = 2$ otherwise. The best for the risk-neutral investors is instead to consume their entire endowment when their marginal utility is highest, that is at $t = 0$. A planner can achieve this allocation by investing in the short asset a sufficient amount to cover the unitary per-capita demand of early consumer in state H, that is $y \geq \omega_H$. This means that rollover is positive in states M and L (and also in state H if $y > \omega_H$). Now, by a continuity argument, when $R \rightarrow 1$ from above the (unique) optimal allocation must converge to one of the optimal allocations for the case $R = 1$ (it can be seen that it converges to the allocation with $y = \omega_H$), but this means that there will be some cutoff $\widehat{R} > 1$ such that whenever $R < \widehat{R}$, rollover is strictly positive in both states M and L. Proposition 1 then implies that no dividend can be paid in state M when R is sufficiently small. ■

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Table 5 – Summary statistics

Variable	Description	Mean	Stan. Dev.	p5%	Median	p95%
IabsTA	Interbank participation in absolute value over total assets	9.66	14.34	0.39	4.72	39.65
CapTA	Capital over total assets	9.02	9.48	3.05	7.04	16.70
DCapTA	Changes in capital over total assets	0.10	5.34	-0.91	0.40	2.52
DepTA	Deposits over total assets	60.92	22.61	16.55	62.31	89.98
ROA	Return on Assets	0.66	0.90	0.00	0.57	18.00
ROE	Return on Equity	7.864	28.717	-0.520	8.780	23.450
LiquTA	Liquidity over total assets	8.37	14.18	0.00	2.37	41.50
LoansTA	Loans over total assets	64.85	22.02	15.16	68.47	92.21
LLP_LOANS	Loans loss provisions over Loans	0.50	1.83	0.01	0.32	1.26
DLoansTA	Changes in Loans over total Assets	5.85	7.88	-3.11	4.82	16.78
DivPayOut	Dividends pay out ratio	38.13	41.11	1.73	26.00	96.27
DDivPayOut	Changes in dividends pay out ratio	3.67	42.18	-33.11	0.85	46.83
LLPNIMR	Loan loss provision over net interest margins	16.38	22.37	0.34	11.45	46.79
DT_TADepFrB	Total amount lent in the interbank market by the other banks per year and country over Total Asset	12.60	4.39	6.24	12.76	20.58
DT_TADueToB	Total amount borrowed in the interbank market by the other banks per year and country over Total Asset	12.45	8.20	0.63	13.54	25.03
DT_TALiqAss	Total liquid assets hold by the other banks per year and country over Total Asset	15.31	8.83	4.41	11.09	27.73
Size	Total asset (US$ billions)	77.89	280.78	1.21	5.94	394.87

Note: All values in percent (unless differently noticed). The sample includes banks from the EU, UK, and Japan with total assets (book value) greater or equal than 1 billion US$ from 2005 till 2008. Data is obtained from Bankscope Database.

Table 6 – Summary statistics by years

Year	2005	2006	2007	2008
Observations	831	927	923	429
IabsTA	9.78%	10.31%	10.15%	6.93%
CapTA	10.18%	9.39%	8.62%	6.87%
DCapTA	0.00%	0.25%	0.16%	-0.31%
DepTA	60.50%	59.29%	59.46%	68.33%
ROA	72.23%	77.40%	69.68%	24.56%
ROE	8.53%	10.52%	8.38%	-0.28%
LiquTA	8.57%	9.23%	8.71%	5.45%
LoansTA	64.53%	64.64%	65.43%	64.66%
LLP_LOANS	0.48%	0.48%	0.53%	0.50%
DLoansTA		6.26%	6.53%	3.68%
DivPayOut	34.91%	36.79%	38.19%	45.53%
DDivPayOut		-1.67%	0.35%	16.66%
LLPNIMR	17.62%	14.36%	15.18%	20.31%
DT_TADepFrB	12.39%	13.16%	12.77%	11.44%
DT_TADueToB	14.24%	13.75%	12.85%	5.33%
DT_TALiqAss	16.47%	16.24%	15.38%	10.94%
Size (US$ billions)	66.63	71.31	76.32	117.28

Note: Summary statistics by years. The sample includes banks from the EU, UK, and Japan with total assets (book value) greater or equal than 1 billion dollars from 2005 till 2008. Data is obtained from Bankscope Database.

Table 7 – Summary statistics by size

Bank Size	1-20 bln	20-100 bln	100-200 bln	>200 bln
Observations	2184	558	130	238
IabsTA	9.43%	11.34%	7.86%	8.72%
CapTA	9.98%	7.56%	6.40%	5.12%
DCapTA	-0.11%	0.65%	0.43%	0.53%
DepTA	65.94%	51.97%	46.81%	42.04%
ROA	69.49%	62.44%	60.35%	51.01%
ROE	7.88%	6.03%	8.39%	11.70%
LiquTA	6.57%	9.38%	9.40%	19.18%
LoansTA	67.89%	62.79%	55.01%	47.16%
LLP_LOANS	0.53%	0.44%	0.34%	0.40%
DLoansTA	5.65%	6.81%	4.78%	6.02%
DivPayOut	35.57%	44.44%	41.51%	44.24%
DDivPayOut	3.60%	4.64%	2.23%	3.02%
LLPNIMR	16.13%	18.33%	14.51%	15.40%
DT_TADepFrB	12.15%	13.17%	13.84%	14.73%
DT_TADueToB	11.21%	14.60%	15.90%	16.91%
DT_TALiqAss	16.08%	12.68%	13.39%	15.89%
Size	5.05	45.63	143.91	785.88

Note: Summary statistics by bank size. The sample includes banks from the EU, UK, and Japan with total assets (book value) greater or equal than 1 billion dollars from 2005 till 2008. Data is obtained from Bankscope Database.

Table 8 – Correlation matrix

	IabsTA	CapTA	DCapTA	DepTA	ROA	ROE	LiquTA	LoansTA	LLP_LOANS	DLoansTA	DivPayout	DDivPaout	LLPNIMR	DT_TAFromB	DT_TAduetoB	DT_TALiqAss	Size
IabsTA	1																
CapTA	-0.143	1.000															
DCapTA	0.014	0.250	1.000														
DepTA	-0.147	-0.434	-0.095	1.000													
ROA	-0.048	0.541	0.204	-0.330	1.000												
ROE	0.010	-0.032	-0.055	-0.005	-0.070	1.000											
LiquTA	0.106	0.252	0.036	-0.447	0.166	-0.013	1.000										
LoansTA	-0.075	-0.038	0.048	0.211	-0.089	0.015	-0.406	1.000									
LLP_LOANS	0.079	-0.046	0.098	0.119	-0.214	-0.015	-0.099	0.176	1.000								
DLoansTA	-0.011	0.105	0.195	0.066	0.066	0.044	-0.052	0.190	-0.069	1.000							
DivPayOut	0.060	0.044	-0.198	-0.212	-0.115	-0.021	0.119	-0.031	0.005	0.000	1.000						
DDivPayOut	0.023	0.097	-0.226	-0.124	-0.130	-0.030	0.038	-0.019	-0.012	0.125	0.759	1.000					
LLPNIMR	0.058	0.056	0.106	-0.014	-0.123	0.001	-0.091	0.185	0.954	-0.081	-0.008	-0.016	1.000				
DT_TADepFrB	0.049	-0.028	-0.217	-0.094	-0.166	-0.070	0.230	-0.012	0.019	-0.031	0.202	0.168	0.000	1.000			
DT_TADueToB	0.079	0.038	0.323	-0.384	0.112	0.048	0.444	-0.101	0.018	0.062	-0.037	-0.175	-0.007	-0.069	1.000		
DT_TALiqAss	0.016	0.054	0.397	-0.030	0.203	0.083	0.120	-0.122	0.018	0.037	-0.215	-0.250	0.010	-0.750	0.585	1.000	
Size	-0.136	0.262	-0.213	-0.404	0.355	-0.132	0.317	-0.353	-0.226	-0.104	0.129	0.019	-0.105	-0.005	-0.012	-0.065	1.000

Note: pairwise correlation matrix of the interbank market participation and the characteristics of the banks. The sample includes banks from the EU, UK, and Japan with total assets (book value) greater or equal than 1 billion dollars from 2005 till 2008. Data is obtained from Bankscope Database.

Table 9 – Relationship between participation in the interbank market and the lagged level of capital.

	(1)			(2)			(3)		
IabsTA	**Coeff.**		**Robust SE**	**Coef.**		**Robust SE**	**Coeff.**		**Robust SE**
LCapTA	-0.122	***	0.029	-0.112	***	0.030	-0.105	***	0.030
LLiquTA	-0.083	**	0.036	-0.081	**	0.035	-0.085	**	0.036
LoansTA	-0.116	***	0.029	-0.119	***	0.029	-0.144	***	0.030
DepTA	0.059	*	0.033	0.057	*	0.033	0.053		0.034
ROA	0.010	**	0.004						
ROE				0.000		0.000	0.000		0.000
Size	-0.007	***	0.002	-0.007	***	0.002	-0.009	***	0.002
LLP_LOANS	1.102	***	0.084	1.073	***	0.070			
LLPNIMR							0.048	**	0.022
DT_TADepFrB	0.163		0.102	0.171	*	0.103	0.165		0.105
DT_TADueToB	0.171	**	0.081	0.168	**	0.082	0.152	*	0.082
DT_TALiqAss	-0.141	***	0.051	-0.140	*	0.052	-0.165	***	0.056
DummyUK	0.008		0.015	0.006		0.015	0.015		0.018
DummyJA	-0.056	***	0.018	-0.060	***	0.018	-0.060	***	0.018
Dummy2006	0.002		0.009	0.005		0.009	0.008		0.009
Dummy2007	0.011		0.009	0.014		0.009	0.019	**	0.009
Constant	0.178	***	0.048	0.187	***	0.048	0.217	***	0.052
N. of obs			1694			1693			1691
R-squared			0.1535			0.1501			0.1302

Note: Linear Regression estimate with Robust standard error of the relationship between the intensity of interbank market participation and bank capital. The intensity of participation to the interbank market is measured as the absolute value of the difference between Deposit from banks and Due to banks. This value is then divided by total assets. The sample period considered ranges from 2005 till the end of 2008. ***indicates statistical significance at the 1% level, **indicates statistical significance at the 5% level, and *indicates statistical significance at the 10% level.

Table 10 – Relationship between change in capital and interbank participation

	(1)			(2)			(3)		
DCapTA	**Coef.**		**Robust SE**	**Coef.**		**Robust SE**	**Coef.**		**Robust SE**
IabsTA	-0.055	***	0.026	-0.045	***	0.015	-0.061	***	0.025
LCapTA	-0.250	***	0.067	-0.249	***	0.065	-0.260	***	0.067
LLiquTA	-0.002		0.005				-0.004		0.005
DLoansTA	0.035	***	0.011	0.038	***	0.009	0.028	**	0.012
LLP_LOANS	0.008		0.027				0.036	*	0.027
DepTA	0.002		0.005				0.004		0.005
ROE	0.000		0.000						
ROA							0.005	**	0.002
Size	-0.001	***	0.001	-0.002	***	0.001	-0.001	***	0.001
DummyUK	-0.002		0.002	-0.002		0.002	-0.002		0.002
DummyJA	-0.013	***	0.005	-0.012	***	0.003	-0.017	***	0.004
Dummy2006	0.007	**	0.003	0.007	***	0.003	0.006	**	0.003
Dummy2007	0.008	***	0.002	0.008	***	0.002	0.007	***	0.002
Constant	0.037	***	0.013	0.038	***	0.011	0.035	***	0.012
N. of obs			1694			1693			1689
R-squared			0.1972			0.1969			0.1932
Kleibergen-Paap rk LM statistic		p value=	0.000		p value=	0.000		p value=	0.000
Hansen J statistic		p value=	0.380		p value=	0.752		p value=	0.349
Instruments:	LoansTA, DT_TADepFrB, DT_TADueToB, DT_TALiqAssZ			LLiquTAZ, LoansTA, DepTAZ, ROEA, LLP_LOANS, DT_TADepFromB, DT_TADueToB, DT_TALiqAssZ			LoansTA, DT_TADepFrB, DT_TADueToB, DT_TALiqAssZ		

Note: GLS Regression estimate with Robust standard error of the relationship between the change of Bank Capital over Total assets and intensity of interbank market participation. The intensity of participation to the interbank market is measured as the absolute value of the difference between Deposit from banks and deposits to banks. This value is then divided by total assets. The variable absolute value of the intensity of the interbank market participation over total assets is instrumented with the instruments indicated in the different columns. The sample period considered ranges from 2005 till the end of 2008. ***indicates statistical significance at the 1% level, **indicates statistical significance at the 5% level, and *indicates statistical significance at the 10% level.

Table 11 – Relationship between change in dividends and interbank participation

	(1)			(2)			(3)		
DDivPayOut	**Coef.**		**SE**	**Coef.**		**SE**	**Coef.**		**SE**
IabsTA	-0.317	**	0.156	-0.283	*	0.152	-0.045		0.671
LCapTA	-0.960	***	0.342	-0.988	***	0.346	-0.833	**	0.383
LLiquTA	-0.201		0.167				-0.121		0.203
LLPNIMR	-0.268	***	0.104	-0.278	***	0.102	-0.316	***	0.107
DepTA	-0.151		0.111	-0.193	*	0.102	-0.171		0.124
DLoansTA	0.616	***	0.278	0.546	**	0.261	0.767	***	0.287
LoansTA	-0.121		0.108				-0.070		0.150
ROE	0.001		0.001				0.001		0.001
Size	0.023	**	0.011	0.022	**	0.010	0.019		0.013
DummyUK	0.102		0.074	0.110		0.073	0.127	*	0.072
DummyJA	0.442	***	0.060	0.474	***	0.056	0.458	***	0.094
Dummy2006	-0.276	***	0.042	-0.274	***	0.042	-0.280	***	0.041
Dummy2007	-0.194	***	0.040	-0.193	***	0.040	-0.206	***	0.039
Constant	-0.319	**	0.157	-0.389	***	0.146	-0.296		0.247
N. of obs			1997			1997			1693
Pseudo R-squared			0.1462			0.1451			
Obs. Summary									
Left-censored observations (at DDivPayOut~Z<=0)			1485			1485			1228
Uncensored observations			512			512			465
Right-censored observations =			0.000			0			
Wald test of exogeneity								P value=	0.7509
Instruments:							DT_TADepFrB, DT_TADueToB, DT_TALiqAss		

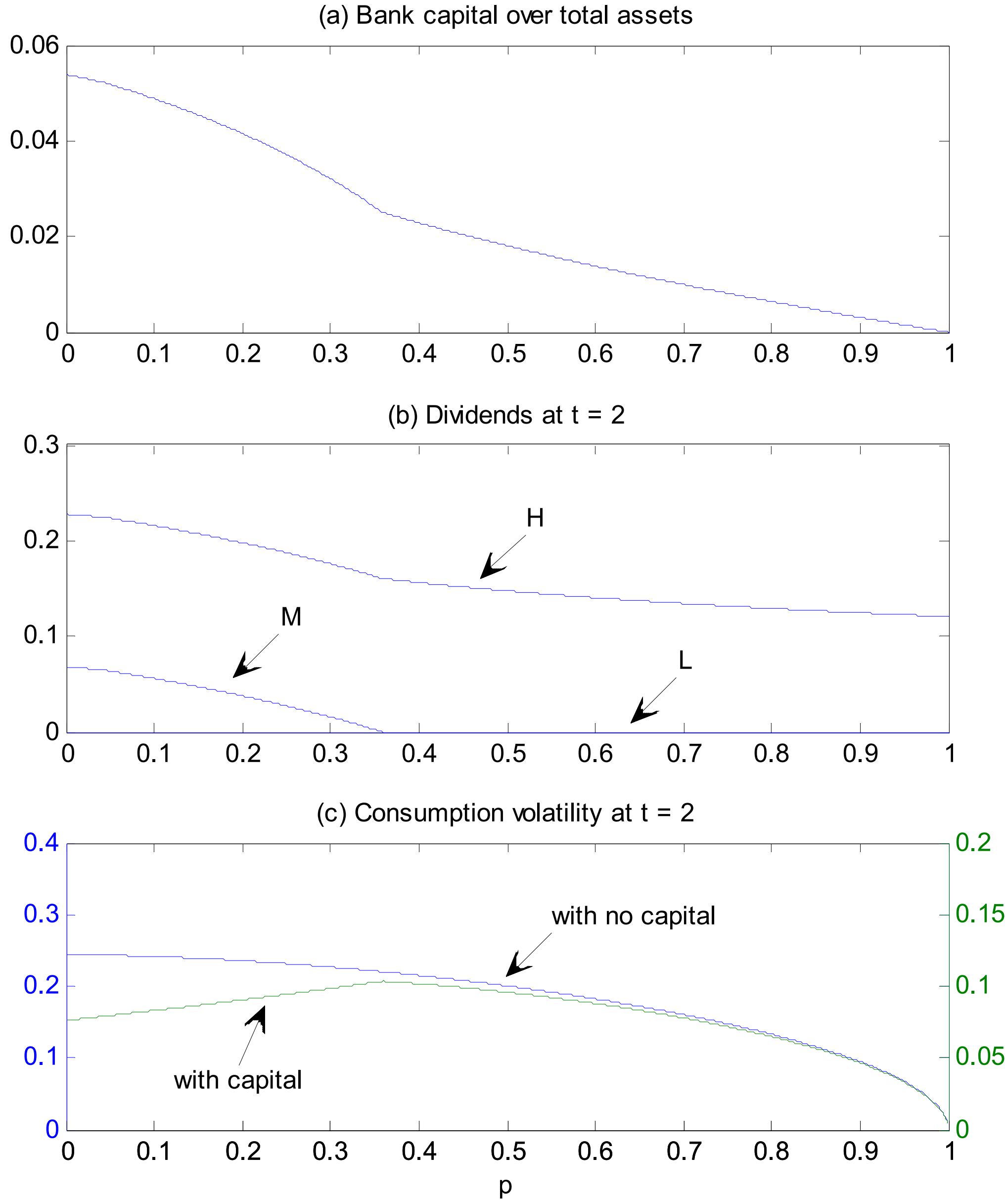
Note: Tobit Regression estimate with of the relationship between the change of Dividend Payout and intensity of interbank market participation. The intensity of participation to the interbank market is measured as the absolute value of the difference between Deposit from banks and deposits to banks. This value is then divided by total assets. Column 3 reports the estimation of the Tobit model with instrumental variables. The variable absolute value of the intensity of the interbank market participation over total assets is instrumented with DT_TADepFromB, DT_TADueToB, DT_TALiqAss. The sample period considered ranges from 2005 till the end of 2008. ***indicates statistical significance at the 1% level, **indicates statistical significance at the 5% level, and *indicates statistical significance at the 10% level.

Table 12 – Relationship between dividends and interbank participation

	(1)			(2)		
DivPayOut	**Coef.**		**Robust SE**	**Coef.**		**Robust SE**
IabsTA	2.260	*	1.372	2.107	*	1.149
LCapTA	-1.307	***	0.362	-1.319	***	0.355
LLiquTA	0.024		0.218			
DepTA	-0.573	***	0.132	-0.560	***	0.123
LoansTA	0.470	**	0.211	0.496	***	0.172
DLoansTA	0.358		0.281			
LLPNIMR	-0.468	***	0.107	-0.485	***	0.106
LLP_LOANS	-3.332	*	1.830	-3.199	*	1.676
ROE	0.001	*	0.001	0.001	*	0.001
Size	0.044	***	0.016	0.044	***	0.015
DummyUK	0.187	**	0.077	0.192	**	0.076
DummyJA	0.728	***	0.156	0.692	***	0.121
Dummy2006	-0.008		0.043	-0.003		0.042
Dummy2007	-0.066		0.046	-0.059		0.044
Constant	-0.590		0.377	-0.571		0.322
N. of obs			1688			1688
Obs. Summary						
Left-censored observations (at DDivPayOut~Z<=0)			775			775
Uncensored observations			913			913
Wald test of exogeneity		P value=	0.0717		Pvalue=	0.045
Instruments:	DT_TADepFrB, DT_TADueToB, DT_TALiqAss			DT_TADepFrB, DT_TADueToB, DT_TALiqAss, LLiquTA, LoansTA		

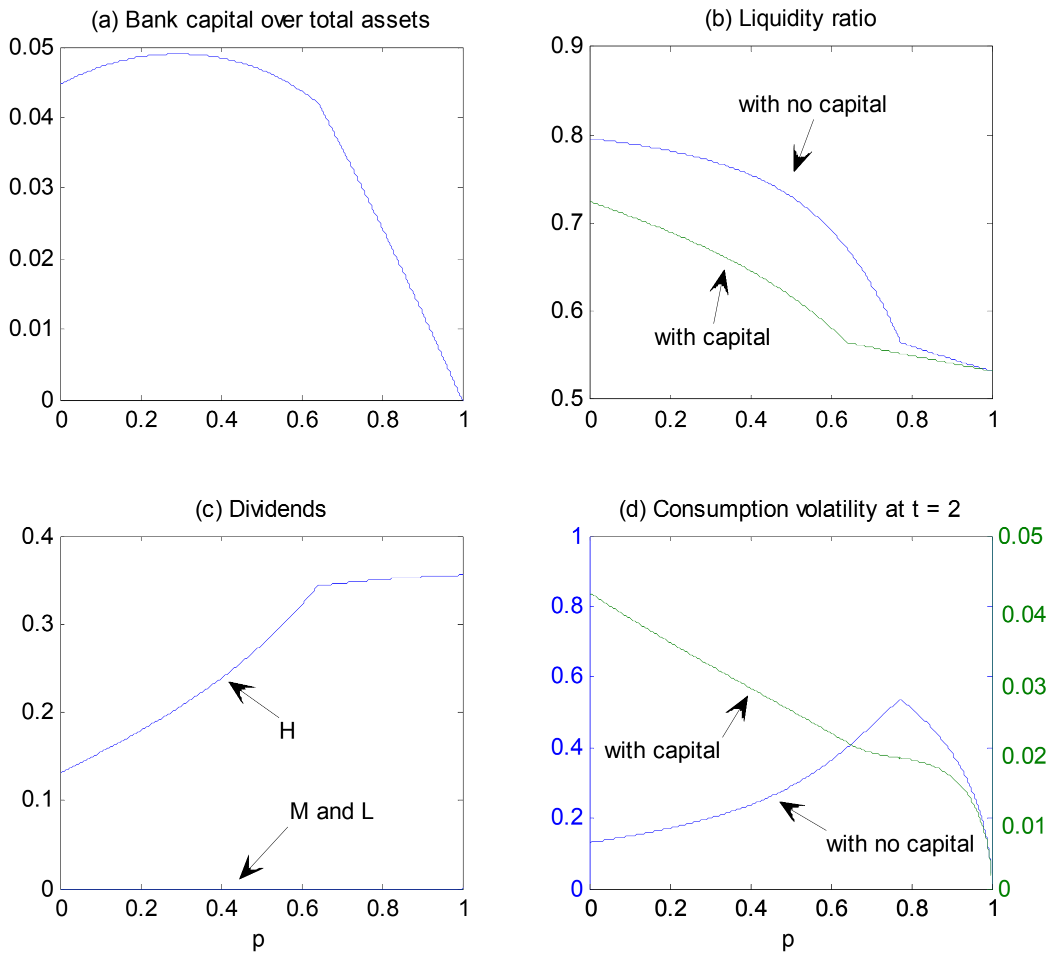
Note: Tobit model estimate with instrumental variables of the relationship between Dividend Payout and intensity of interbank market participation. The intensity of participation to the interbank market is measured as the absolute value of the difference between Deposit from banks and deposits to banks. This value is then divided by total assets. The instrumented variable is the absolute value of the intensity of the interbank market participation over total assets. The sample period considered ranges from 2005 till the end of 2008. ***indicates statistical significance at the 1% level, **indicates statistical significance at the 5% level, and *indicates statistical significance at the 10% level.

Figure 1
Bank capital for different values of p



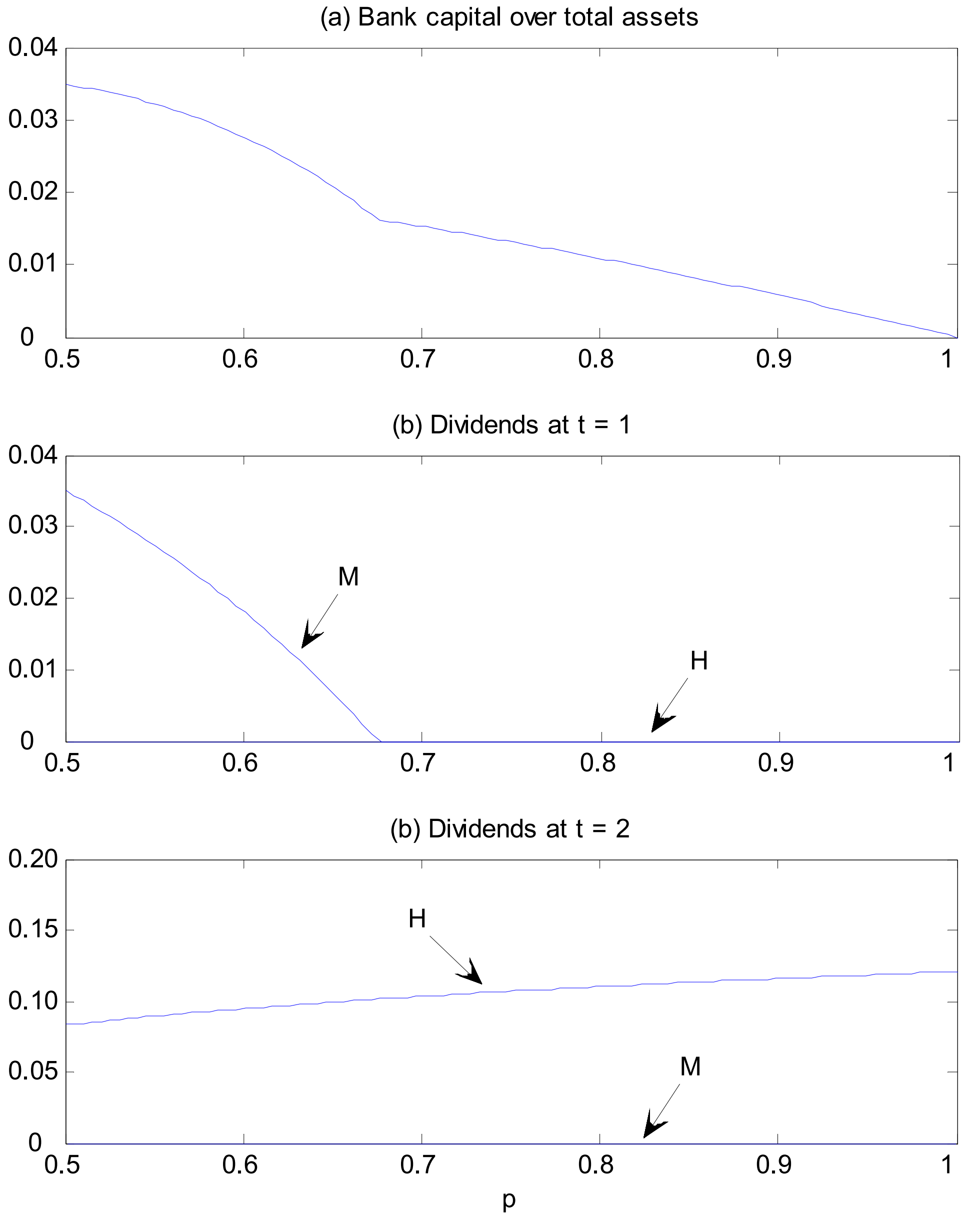
Note: The parameters are $\gamma = 2$, $R = 1.8$, $\rho = 2$, $\omega_H = 0.6$, $\omega_L = 0.4$.

Figure 2
Bank capital for different values of p



Note: The parameters are $\gamma = 2$, $R = 1.3$, $\rho = 1.4$, $\omega_H = 0.8$, $\omega_L = 0.2$.

Figure 3
Dividends at both t = 1 and t = 2



Note: The parameters are γ = 2, R = 1.8, ρ_0 = 2, ρ_1 = 1.75, ω_H = 0.6, ω_L = 0.4, q = 1. With the exception of q and ρ_1, parameters are as in Figure 1.