Strategic competition on the deposit market during banking crises*

Jung-Hyun Ahn†
NEOMA Business School

Michael Brei‡
University of Lille

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Abstract

The present paper investigates the competitive behavior of banks in the deposit market of the United States during the financial crisis of 2007-09. We argue that the largest banks are not passive receivers of deposits, rather those with a stable deposit base have been engaged in deposit competition with the aim of increasing market power in the future. For this purpose, we propose a simple theoretical model of deposit competition, in which stable banks may have an incentive to conduct such a strategy to the extent that the current costs associated with the attraction of deposits (spread on deposits) are lower than the future expected benefits associated with the increase in market power, stemming from the disadvantage distressed competitors incur due to heightened competition. Our empirical analysis confirms the theoretical predictions: the deposit market share of large and stable banks during the financial turmoil has increased in response to abnormal increases in deposit spreads in the core deposit segment. In other words, the evidence suggests that large banks effectively conducted aggressive competition during this period.

Keywords: deposit market, banking competition, banking crisis

JEL: G21, L12, L13

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†Corresponding author, jung-hyun.ahn@neoma-bs.fr

‡michael.brei@univ-lille.fr

I. Introduction

This paper investigates the competitive behavior of banks in the US deposit market during the recent financial crisis. The crisis of 2007-09 and its repercussions on the real economy have changed the landscape of the banking sector in many aspects. Apart from triggering large-scale rescue packages, unconventional monetary policies and significant changes in bank regulation, the banking sector itself has experienced an increase in bank concentration. This process is in part explained by the large number of mergers and acquisitions of troubled and failed institutions by their competitors.[1]

Along with the wave of consolidation, there have been large in- and outflows of deposits at particular banks. Inflows of deposits have been more striking at large banks and in core deposit segments as is shown in Figure 1, however, the increase of deposits at large banking institutions has not been distributed equally. While a number of major banks have benefited from inflows of deposits, others have lost their deposit base or even went out of business during the 2007-09 financial crisis.[2] In this paper, we investigate the forces behind this unequal distribution of deposits, in particular, focusing on large banks. As we argue that the strategic behavior by banks in the deposit market has contributed to the reshuffling of deposits in large banks.

The inflow of deposits into large banks and into the core deposit segment is in line with the well-established literature on the flight to the safe haven. Facing extreme market stress, depositors are looking for a safe shelter to preserve their cash, such as implicit government guarantees of large and systemically important banks or explicit guarantees for insured deposits (core deposits) (Santos, 2014; Farhi and Tirole, 2009; Diamond and Rajan, 2009).

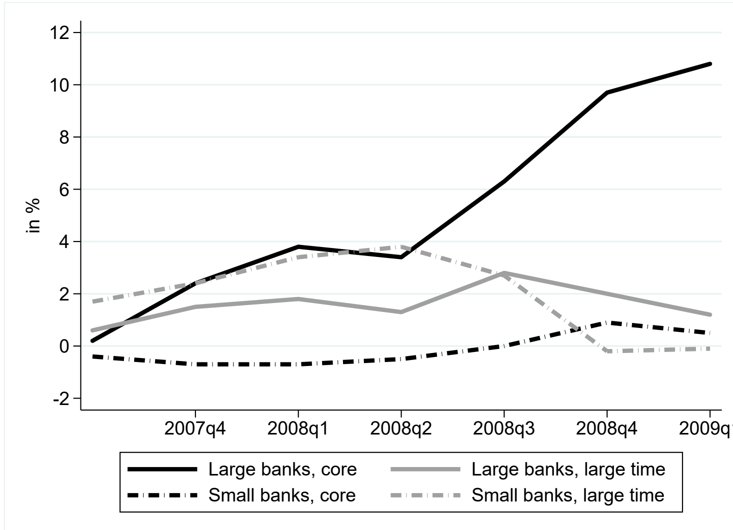
On the other hand, the existing literature on market discipline, such as Flannery (1998), argues that banks undergoing difficulties during a crisis are institutions that are jeopardized by excessive risk taking prior to the crisis in combination with weak fundamentals, such as excessive leverage or the heavy reliance on short-term funding. In the same vein, Berger and Bouwman (2013) demonstrated that well-capitalised banks are more likely to survive than those with weak capital position. It follows that banks in strong position have a natural competitive advantage during the crisis and may receive more deposits inflows from their competitors in difficulty even though this literature does not address explicitly the behavior of depositors during the crisis.

In this paper, we argue that there exists a further explanation on this unequal redistribution

[1] During the period 2008-2010, the US banking system has experienced 361 bank failures and 689 mergers and acquisitions of FDIC-insured institutions, involving close to 2 trillion USD of assets (Brei et al., 2014). Concurrently the number of commercial banks has decreased from 7,335 in 2006 to 6,478 in 2010.

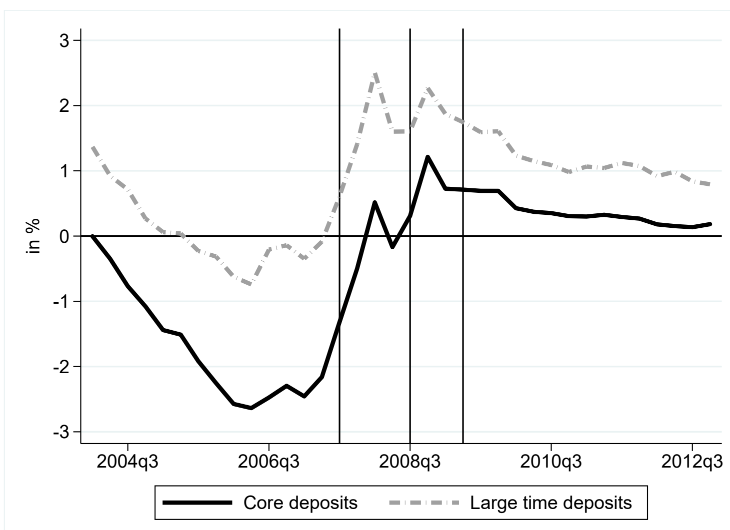
[2] According to our estimation based on the U.S. Call report data, among 154 FDIC-insured institutions with total assets above USD 1 billion, roughly two-thirds of them (107 institutions) have experienced inflows of deposits whereas one-third of them have seen their deposit base shrinking. While 23 institutions have lost all of their deposits, 22 institutions either failed or were acquired by other institutions.

Figure 1: Cumulative deposit growth



Source: Acharya and Mora (2015)

Figure 2: Weighted average spread of deposit rate over 3-month US T-bill rate



For the 99th percentile largest banks in terms of total deposits. Source: Authors' estimation from US Call reports.

of deposits across banks, that are rooted in strategic behavior in the market for deposits by banks which were not in difficulty during the crisis. To be more precise, it could be that those banks that experienced important deposit inflows may not have just been passive receivers of deposits. They may have been engaged in aggressive competition to attract the deposits from distressed banks on the one hand and, even more, with the aim of increasing market power and consequently profits in the future taking advantage of their stable positions.

There are several reasons our hypothesis are plausible. Deposits are a cheap and stable source of funding for banks during normal times (Kashyap et al., 2002; Gatev and Strahan, 2006). However, when facing a financial turmoil during which banks with higher liquidity- and solvency-risk experience difficulty to retain their deposits, despite the fact that deposits are insured by the FDIC up to a certain amount, there might be a good opportunity for the other banks to collect or even attract those funds.[3]

On the other hand, it is well documented that there exist switching costs when depositors change their banks, especially for core deposits (Kiser, 2002; Shy, 2002; Brown et al., 2020; Brunetti et al., 2016). Given that banks in difficulty (or believed to be in difficulty) are constrained in competition, stable banks might to be in position to make an attractive offer to compensate for the switching cost. In the extreme case, large and stable banks might even pursue more aggressive strategies that involve weakening or driving out their rivals under distress even only temporarily with the purpose of increasing market power and firm value.

Anecdotal evidence documented by journalists and academics on the strategic behavior of banks during the financial crisis suggests that there might be some banks that have taken advantage of their strong position to increase their market share on the back of competitors (Berger and Bouwman, 2013; Bandell, 2010; Gamble, 2010).[4]

A couple of indirect indicators on the aggregate level on the deposit market suggest as well a possible existence of deposit reshuffling resulted from strategic behavior by banks. Figure 2 shows the average spread of large banks' interest rate on deposits and the 3-month U.S. Treasury bills rate, which can be considered as a (imperfect) proxy of competition intensity in deposit market. In spite of the decrease in interest rates from 2007q4, the spread exhibits a different trend and it remains particularly high during the financial crisis with two peaks at 2008q1 and 2008q4 for both core and large time deposit segments. This observation is compromising with our hypothesis

[3]For instance, Iyer and Puri (2009) show that depositors ran from a fundamentally sound bank when a nearby bank failed and that deposit insurance was only partly successful at limiting outflows of insured deposits.

[4]See for example, American banker, October 9, 2008 "Deposit-Gathering Pitches Evolving Amid Upheaval", which reported abnormally high deposit rates in part due to JP Morgan and Wells Fargo as well as several deposit collection campaigns run by several large banks during the crisis. Bandell (2010) documents that JP Morgan's advertizing campaign in South Florida has been followed by an 1.3 percent increase in its deposit market share. Gamble (2010) investigates the shift of deposits from commercial banks to credit unions and the difficulty they were facing in managing the large inflows.

that the unequal distribution of deposits among large banks has (at least in part) resulted from aggressive competition presumably driven by stable banks on the back of those in difficulty.

Against these backdrops, the present paper examines theoretically and empirically the strategic behavior of banks in the deposit market. First, we propose a theoretical model in which banks conduct price competition using the deposit rate to analyze whether and under which circumstances a bank has an interest to conduct aggressive competition. In a Hotelling-type model of competition by 2 banks with 2 time periods inspired by Matutes and Vives (1996), we demonstrate that banks in a strong position may have incentives of driving out their competitor, even if it is costly in the short-term. This occurs when the current costs associated with the attraction of deposits are lower than future expected benefits of the drive-out strategy associated with increased market power. The incentives of driving out competitors are especially pronounced in environments in which competitors experience adverse financial shocks because the drive-out strategy becomes less costly to the extent that attracting depositors from the competitor is easier than during normal times.

Second, we test econometrically the theoretical predictions using US bank level data from the Call Reports of FDIC-insured commercial banks from the United States. We use deposit spreads, computed by the difference between deposit rates and the 3-month U.S. Treasury bill rate (proxy for the market risk-free interest rate), as a strategic variable for price competition and test whether there is evidence of aggressive behavior by banks in a strong position. Based on a 2-stage regression approach in order to control for the utilization of the deposit spread for aims other than the purpose of our hypothesis, the results suggest that the deposit market share of large banks during the financial turmoil has increased in response to abnormal increases in deposit spreads. In other words, there is evidence that large banks effectively conducted aggressive competition during this period.

The results of our analysis raise some important policy implications given that the battle for deposits potentially has an impact on the welfare of the economy. If large banks take advantage of the financial turmoil and their implicit privilege to drive-out temporarily liquidity-constrained but solvent competitors, then this could contribute to financial stress and ultimately lead to a higher concentration in the deposit market. This suggests that increases in the market share by large banks during financial turmoil require particular attention by the regulator.

Our paper is related to several strands of literature. First, our analysis is related to the literature on banks' deposit behaviors. There are several papers which analyze the deposit from macroeconomic perspective. Kashyap et al. (2002) and Gatev and Strahan (2006) analyzed the role of banks as a liquidity provider during the crisis. Acharya and Mora (2015) demonstrated its collapse during the 2007-9 financial crisis. Drechsler et al. (2017) analyze how deposit rates react to the monetary policy. However, relatively few papers focus directly on strategic behavior of banks in the deposit market during the crisis. Martin et al. (2018) analyzed deposit behavior in a distressed bank using detailed deposit data of a failed bank. Egan et al. (2017) demonstrated that competition for insured deposits propagates financial distress across banks: distressed banks have incentives for overbidding on interest rates on insured deposits, which in turn drives non-distressed banks to raise their interest rate above the one offered by the distressed bank in order to keep their insured deposits. In our paper, we argue that non-distressed banks did not necessarily increase their interest rate in a passive way but may have been interested to do it, in order to attract uninsured deposits of distressed banks or insured and uninsured deposits from failing banks.

Second, a strand of literature analyzes the predatory behavior of financial institutions for the purpose of weakening their competitors in the interbank and capital markets (Acharya et al., 2012; Brunnermeier and Pedersen, 2005; Carlin et al., 2007). We demonstrate that banks may have also an interest to follow similar strategies in the deposit market when a severe crisis hits the financial system.

Finally, we add to the theoretical analysis on the competition between banks on deposit market. There exist abundant theoretical literature on strategic behavior of banks in credit market (Ahn and Breton, 2014; Broecker, 1990; Hauswald and Marquez, 2006; von Thadden, 2004) while relatively few studies investigate theoretically strategic behavior of banks in deposit markets. Matutes and Vives (1996) investigate the relationship between deposit competition and instability under the presence of travel cost of depositors. Shy et al. (2016) examine the impact of deposit insurance on deposit competition.

The remainder of the paper is organized as follows. Section II develops a theoretical model of banking competition for the market for deposits and investigates under which circumstances a bank conducts aggressive behavior. Section III presents the data and empirical strategy to investigate whether we can find econometric evidence on such behavior. Section IV presents the main results of the baseline model and further empirical analysis. Section V concludes.

II. Theoretical model

This section provides a theoretical model to explain why and under which circumstances banks might it find optimal to conduct aggressive competition in the deposit market. Aggressive competition hereby occurs when a bank seeks to drive out its liquidity-constrained competitor during a financial crisis. The model environment is discussed in subsection A, whereas banks' behavior in the face of a (temporarily) distressed competitor is investigated in subsections B and C.

A. Environment

The strategic interaction of banks on the deposit market is investigated within a simple dynamic competition of two periods in the deposit market composed of two banks. In each period, they compete for deposits *à la* Hotelling (see, Matutes and Vives (1996)). There exists a continuum of individuals who decide on whether depositing their funds at a particular bank or not, depending on the location of banks and the deposit rate. The two banks offer a deposit contract to individuals, taken their location as given, to invest the received funds in a risky asset portfolio from which they earn an expected return.[5] The return is assumed to be perfectly observable by depositors and the competitor bank and it is subject to shocks in the first period.

A.1. Banks

There are two banks, A and B, which are located at 0 and 1 on a unit segment, respectively. As said, they compete on a deposit market. In our theoretical analysis, for the tractability, we consider only deposit rate as a strategic variable although our analysis and main result can be generalized to the case of other strategic variables, for instance fees on deposit account or marketing and advertisement expenses for deposit collection. We will take these variables into consideration, together with deposit rate in the empirical analysis section.

Banks have no initial endowment but can raise funds from depositors by offering a standard debt contract with a fixed gross deposit rate r_{it} ($i = A, B$, $t = 1, 2$). The repayment, however, is uncertain.[6] Bank i invests in turn the deposits in an asset (or an imperfectly diversified portfolio), which yields a return of R with probability p_{it} and zero with probability $1 - p_{it}$. The success probability can be interpreted in terms of the riskiness of bank i in period t. Note that for simplicity we assume that a bank's riskiness is perfectly observable by depositors and its rival, although a transparency parameter could be introduced. We denote by D_{it} the deposit market share which implies that bank i's expected profit in period t, π_{it}, is given by:

$$\pi_{it} = D_{it}(r_{it}, r_{jt})\, p_{it}\,[R - r_{it}]$$

Without loss of generality, we abstract from a discount factor and thus bank i's overall profits are:

$$\Pi_i = \pi_{i1} + \pi_{i2}$$

We assume that, if a bank is out of the market in the first period, *i.e.* it cannot attract any depositor, it will not be present in the second period.

With regard to the banks' riskiness or success probability, we assume that

$$p_A = p_{A1} = p_{A2} \tag{1}$$
$$p_B = p_{B2} \geq p_{B1} \tag{2}$$
$$p_A > p_B \tag{3}$$

[5]The assumption that each bank's location (or proximity to a depositor's preferences) is given can be justified by the fact that we focus on the strategic decisions on deposit rates in a relatively short term horizon.

[6]By this assumption, deposits are considered as uninsured, although it might also reflect that depositors dislike any uncertainty about a bank being closed, since it may take time until insured deposits are repaid.

By (3), we assume that bank A has a higher success probability than bank B, and therefore it is bank A that is potentially interested in conducting an aggressive strategy. By (2), it is supposed that bank B can be in a distressed situation during the first period 1 in which case $p_{B1} < p_B$. Without any loss of generality, it is assumed that bank A not to be affected by the crisis. Alternatively, one might interpret bank A as a too-big-to-fail institution for which the perceived risk p_A is not affected during a crisis. We assume as well

$$(p_A - p_B)R < 3c \tag{4}$$

by which bank A cannot be a (natural) monopoly when bank B is not hit by a shock in the first period.

A.2. Depositors

Depositors are uniformly distributed on a unit segment $[0, 1]$ between the two banks and they are risk neutral. In each period, they are endowed with one unit of funds with a reservation value r_0, interpreted as the return on a risk-free outside option.[7] Depositors face a constant marginal transportation cost $c > 0$ and decide whether to deposit their endowment in a particular bank or not.[8]

Given p_{it}, a depositor's expected surplus depositing at bank i with a distance of d is then given by

$$S_{it} = p_{it}r_{it} - c \cdot d \tag{5}$$

A.3. Timing

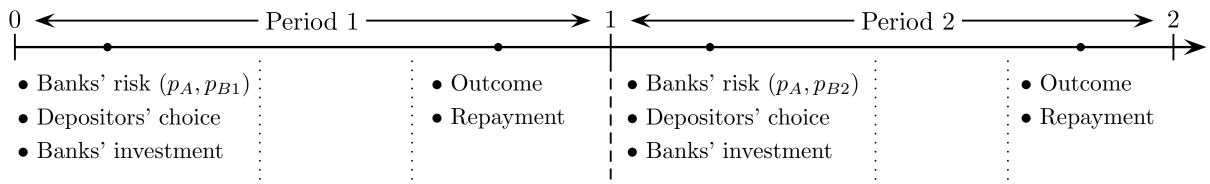
- $t = 0$: Period 1 begins. Depositors observe the riskiness of each bank (p_A, p_{B1}) and either choose a bank to deposit their endowment or to invest in a risk-free asset. Banks invest in an asset if they withdraw their deposits. Banks which cannot collect deposits are out of business.
- $t = 1$: The return is realized and banks repay their depositors; Period 2 begins. Depositors observe the riskiness of each bank (p_A, p_{B2}) in period 2 and either choose a bank to deposit or to invest in a risk-free asset. Banks invest in an asset if they withdraw their deposits.
- $t = 2$: The return is realized and banks repay their depositors.

The timing is illustrated in Figure 3.

[7] It can be considered as the return on an alternative for bank deposits, such as money market mutual funds.

[8] The transportation costs of the depositor need not be necessarily a physical cost of traveling to the bank, they can also be interpreted as a disutility due to the difference between the preferred deposit services of a depositor and the services offered by a bank. Banks could in principle differentiate their deposit services, not only by the deposit rate, but also by different combinations of consumer credit facilities, ATM network size etc.

Figure 3: Timing



We solve the model by backwards induction and characterize subgame perfect Nash equilibria.

B. Second-period competition

We first consider second-period competition given the outcome of the first period. Upon the outcome, either both banks survived in first period and are present in the second period or only one bank is present.

B.1. Monopoly

When bank i becomes a monopoly supplier in period 2, its profit given the deposit rate r_{i2} is described by

$$\pi_{i2}(r_{i2}) \quad = \quad \max\left\{\bar{d}_{i2}(r_{i2}), 1\right\} \times p_{i2}[R - r_{i2}] \tag{6}$$

where $\bar{d}_{it}(r)$ is defined as the distance to bank i's marginal depositor who is indifferent between depositing in bank i and holding the risk-free asset given the deposit rate r in period t. More specifically, for the marginal depositor it must be true that

$$\bar{d}_{it} \equiv \frac{p_{it} r_{it} - r_0}{c} \tag{7}$$

with $t = 2$. Simple maximization yields the optimal deposit rate and subsequent monopoly profits:

Lemma 1. *1. When $p_{i2}R < r_0 + 2c$, monopolist bank i fixes its deposit rate at $r_{i2}^* = \frac{p_{i2}R + r_0}{2p_{i2}}$ and collects the amount of deposits equal to $\bar{d}_{i2}(r_{i2}^*)$ in period 2.*

2. When $p_{i2}R \geq r_0 + 2c$, monopolist bank i fixes its deposit rate at $r_{i2}^* = \frac{r_0 + c}{p_{i2}}$ and collects the amount of deposits equal to 1 in period 2.

3. Monopoly profits of bank i in period 2 are given by

$$\pi_{i2} \equiv \pi_{i2}^M = \begin{cases} \frac{1}{4c}(p_{i2}R - r_0)^2 & \text{if } p_{i2}R < r_0 + 2c \\ p_{i2}R - r_0 - c & \text{if } p_{i2}R \geq r_0 + 2c \end{cases} \tag{8}$$

B.2. Direct competition

Now we analyze the case in which both banks are present in the second period. Here we limit our analysis focusing on the direct competition equilibrium in which both banks are active and share the whole deposit market as a result of competition.[9] Let $\tilde{d}_{it}(r_{it}, r_{jt})$ denote bank i's marginal depositor who is indifferent between depositing at bank i and bank j, given the deposit rates r_i and r_j offered by both banks in period t

$$\tilde{d}_{it} \equiv \frac{p_{it}r_{it} - p_{jt}r_{jt} + c}{2c} \tag{9}$$

Bank i's deposit market share in period 2 can be expressed as $\tilde{d}_{i2}(r_{i2}, r_{j2})$. Given r_{i2} and r_{j2}, bank i's profit in the period-2 sub-game is therefore:

$$\pi_{i2}(r_{i2}, r_{j2}) \ = \ \tilde{d}_{i2}(r_{i2}, r_{j2}) \times p_{i2}[R - r_{i2}] \tag{10}$$

The first-order condition which determines bank i's best response r_{i2}, given r_{j2}, is therefore:

$$r_{i2}^{BR}(r_{j2}) \equiv \frac{p_{i2}R + p_{j2}r_{j2} - c}{2p_{i2}} \tag{11}$$

This yields the following lemma:

Lemma 2. *Under (4) and $(p_A + p_B)R > 2r_0 + 3c$, the subgame competitive equilibrium is characterized by*

$$\begin{aligned} r_{it}^* &= \frac{2p_{it}R + p_{jt}R - 3c}{3p_{it}} \equiv r_{it}^c \\ D_{it}^* &= \frac{p_{it}R - p_{jt}R + 3c}{6c} \equiv D_{it}^c \\ \pi_{it}^* &= \frac{1}{18c}(p_{it}R - p_{jt}R + 3c)^2 \equiv \pi_{it}^c \end{aligned}$$

where all subscript $t = 2$ and r_{i2}^c, D_{i2}^c and π_{i2}^c are respectively equilibrium deposit rate, equilibrium deposit market share and equilibrium profit.

Proof. r_{i2}^c is obtained from (11). Substituting (11) and (10) for r_A^c and r_B^c yields D_i^c and π_i^c. Since banks compete directly in equilibrium, the marginal depositor derives a non-negative net expected return from the offer by both banks, which is higher than the outside option. This implies that $p_{i2}r_{i2}^* - D_{i2}^*c > r_0$ yielding the condition $(p_A + p_B)R > 2r_0 + 3c$. □

[9] For example, local monopoly is one of the configurations other than direct competition. We exclude all cases other than direct competition under the presence of two banks because it renders analysis complex without shedding further insights with regard to our focus. See Economides (1984) and Matutes and Vives (1996) for complete configurations of this Hotelling-type competition upon parameters.

C. First-period competition and overall equilibrium

In this subsection, we characterize the equilibrium in the first period. Banks make their strategic decision taking the second-period outcome into account. We characterize two types of equilibrium. We first characterize an equilibrium in which the two banks coexist in the two periods (non-aggressive competitive equilibrium), and then we turn to the discussion of an equilibrium in which the stronger bank (or too-big-to-fail) bank drives the weaker bank out of the market by aggressive price setting on the deposit market in the first period (driving-out equilibrium).

C.1. Non-aggressive competition

In the non-aggressive competitive equilibrium, the two banks are active in the two periods and they share the deposit market. More concretely, we characterize an equilibrium in which the deposits rates of the two banks in the first period in a same way as is determined in period-2 competitive equilibrium. This equilibrium only exists, if it is not profitable for banks to deviate from the competitive equilibrium strategy.

Note that competitive equilibrium deposit rate r_{it}^c is the profit maximizing rate given competitors deposit rate r_{jt}^c in each period. Thus, deviating the deposit rate from this level will decrease the profit in that period. Therefore, a bank will be interested in deviation from r_{it}^c only when it can earn more in the second period by deviation in the first period. In other words, banks might have an incentive in period 1 to drive the other bank out of the market by overbidding in order to gain the monopoly profit in period 2. This strategy is costly since overbidding in period 1 reduces the profit in the first period compared to the competitive equilibrium whereas it allows the deviating bank to enjoy monopoly profit in period 2, which is higher than the competitive equilibrium profit. A bank will deviate from the deposit rate of the competitive equilibrium in period 1, r_{i1}^c, if the increase in period-2 profits by becoming a monopoly is higher than the decrease in period-1 profits associated with drive-out strategy compared to competitive equilibrium profits.

Denote $r_{it}^D(r_{jt})$ the minimum driving-out deposit rate given competitor's deposit rate r_{jt}, at which bank i becomes the monopoly bank on the deposit market in the two periods by driving its competitor out of market in the first period with $D_{it} = 1$:

$$r_{it}^D(r_{jt}) \equiv \frac{p_{jt} r_{jt} + c}{p_{it}} \qquad (12)$$

Replacing r_{jt} by the deposit rate of the other bank r_{j1}^c in period 1, $r_{i1}^D(r_{j1}^c)$ is given by

$$r_{i1}^D(r_{j1}^c) = \frac{p_{i1} + 2p_{j1}}{3p_{i1}} R$$

Since $r_{i1}^D(r_{j1}^c) \leq R$ should be satisfied, the driving-out strategy is only feasible for bank A given that $p_A > p_{B1}$. When bank A deviates from the competitive equilibrium deposit rate to drive bank

B out of the market by bidding $r^D_{A1}(r^c_{B1})$, the first-period profit of bank A is given by:

$$\pi_{A1}\left(r^D_{A1}(r^c_{B1}),\, r^c_{B1}\right) \;=\; p_A\left[R - r^D_{A1}(r^c_{B1})\right]$$

From the above it follows that bank A does not find it optimal to follow the drive-out strategy, $r^D_A(r^c_{B1})$, if

$$\underbrace{\pi^M_{A2} - \pi^c_{A2}}_{\text{increase in period-2 profit by aggressive competition}} \quad\leq\quad \underbrace{\pi^c_{A1} - \pi_{A1}\left(r^D_{A1}(r^c_{B1}),\, r^c_{B1}\right)}_{\text{decrease in period-1 profit by aggressive competition}} \tag{13}$$

There exists a non-aggressive competitive equilibrium if the above condition holds.

C.2. Aggressive competition: Driving out the distressed competitor

Now, we characterize the driving-out equilibrium in which only one of the two banks is active in the market. If such a equlibrium exists, it shouhld be $r^*_{i1} = r^D_i(R)$. (Strictly speaking, $r^*_{i1} = r^D_i(R) + \epsilon$ with ϵ being small and positive.) On the one hand, offering a deposit rate lower than $r^D_i(R)$ cannot drive its competitor out of the market because the competitor always has a rate lower than or equal to R, which allows the bank to exist in the market and to make a non-negative profit. On the other hand, banks have no incentive to offer a deposit rate in period 1 that is higher than $r^D_{i1}(R)$ for the purpose of driving out the competitor. At $r^D_{i1}(R)$, bank i can take the entire deposit market. Offering a higher rate will only reduce the profit without any further effect.

It is noteworthy that $r^D_{B1}(R) > R$ and as a result, bank B cannot pursue such a strategy because this will be associated with bank B having negative profits. We can thus conclude that bank A will be a monopoly in equilibrium if a driving-out equilibrium exists. The driving-out strategy is feasible for bank A when $r^D_{A1}(R) \leq R$, which leads to the condition

$$(p_A - p_{B1})R \geq c \tag{14}$$

In what follows, we will analyze when the above driving-out strategy by bank A can establish an equilibrium. Given $r^*_{A1} = r^D_{A1}(R)$ (strictly speaking, $r^D_{A1}(R) + \epsilon$) bank B has no profitable deviation from $r_{B1} = R$. At any deposit rate, bank B will not be able to attract a depositor and be out of the market. Now consider bank A. Given $r_{B1} = R$, deviation from $r^D_{A1}(R)$ by offering a rate below $r^D_{A1}(R)$ will increase profits in period 1 whereas it will decrease profits in period 2 because bank B will survive in period 1 at such a rate and thus will lead to competitive equilibrium in period 2. Among r lower than $r^D_{A1}(R)$, $r^{BR}_{A1}(R)$ is the r_A that makes the highest profit in the first period given $r_{B1} = R$[10]. Thus, bank A find it optimal to remain at $r_{A1} = r^D_{A1}(R)$ if the difference between monopoly profits and competitive profits in period 2, in other words decrease in profits

[10] $r^{BR}_A(R) < r^D_A(R)$ always holds under (4).

by deviation is bigger than or at least equal to the increase in profits in period 1 choosing $r_{A1}^{BR}(R)$ instead of $r_{A1}^{D}(R)$. In other words:

$$\underbrace{\pi_{A2}^{M}-\pi_{A2}^{c}}_{\text{decrease in period-2 profit without aggressive strategy}} \geq \underbrace{\pi_{A1}\left(r_{A1}^{BR}(R),\, R\right)-\pi_{A1}\left(r_{A1}^{D}(R),\, R\right)}_{\text{increase in period-1 profit without aggressive strategy}} \tag{15}$$

C.3. Overall equilibrium characterization

We have the following proposition:

Proposition 1. *Given that $p_{B1}R \geq r_0$ (the riskiness of bank B in the first period when affected by a shock), we have the following:*

1. *When $\pi_{A2}^{M}-\pi_{A2}^{c} < \Delta\pi_1^{devc}$, then we have competitive equilibrium in which bank A and B coexist overall 2 periods.*

2. *When $\pi_{A2}^{M}-\pi_{A2}^{c} > \Delta\pi_1^{devd}$, we have driving-out equilibrium in which bank A has monopoly in the market and bank B shut down even though it can make a revenue higher than risk-free asset ($p_{B1}R \geq r_0$).*

$\Delta\pi_1^{devc}$ and $\Delta\pi_1^{devd}$ are respectively

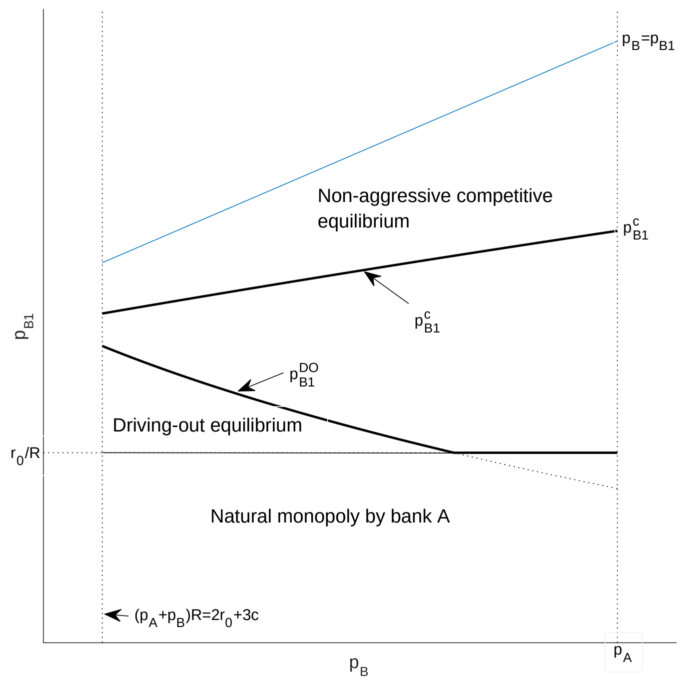
$$\begin{aligned}
\Delta\pi_1^{devc} &= \frac{1}{18c}\left(p_A R - p_{B1}R + 3c\right)^2 - \frac{2}{3}\left(p_A - p_{B1}\right)R \\
\Delta\pi_1^{devd} &= \frac{1}{8c}\left(p_A R - p_{B1}R + c\right)^2 - \left(p_A R - p_{B1}R - c\right)
\end{aligned}$$

$\pi_{A2}^{M}-\pi_{A2}^{c}$ stands for the difference between monopoly profit and competitive equilibrium profit in period 2. $\Delta\pi_1^{devc}$ represents the cost incurred by conducting driving out strategy deviating from competitive equilibrium in period 1. $\Delta\pi_1^{devd}$ is the maximum gain that can be obtained by renouncing driving-out strategy in period 1.

Figure 4 illustrates our result, given p_A. We restrict our attention on the case in which there would be competitive equilibrium if bank B were not affected by distress in period 1.[11] Let p_{B1}^{c} denote p_{B1} such that $\pi_{A2}^{M}-\pi_{A2}^{c}=\Delta\pi_1^{devc}$. Let p_{B1}^{DO} denote p_{B1} such that $\pi_{A2}^{M}-\pi_{A2}^{c}=\Delta\pi_1^{devd}$. p_{B1}^{c} represents the threshold of p_{B1} given p_A above which bank A remains non-aggressive competitive equilibrium. p_{B1}^{DO} represents the threshold of p_{B1} given p_1 below which bank A conducts aggressive competition to drive its competitor B out of the market. Our result is summarized in the following proposition.

[11] We focus only on the right-hand side of the line ($(p_A+p_B)R = 2r_0+3c$). There does not exist direct competition between two banks and banks enjoy their local monoploy on their corner in the case with the left-hand side of this line.

Figure 4: Equilibrium characterization



Proposition 2. *Under the parameters with which bank A remains non-aggressive competitive equilibrium when there is no shock (normal times), we obtain the following results:*

1. *(Non-aggressive competitive equilibrium) When bank B is not hit by a shock or is hit by a shock with relatively small scale in period 1, in other words $p_{B1} > p^c_{B1}$, bank A remains non-aggressive competitive strategy and bank A and B coexist.*

2. *(Shut-down of bank B by its unprofitability) When bank B is hit by a shock with huge scale in period 1, in other words $p_{B1} < \frac{r_0}{R}$, bank B shut down because it is not profitable. Bank A becomes the only bank in the market.*

3. *(Driving-out equilibrium) When bank B is hit by a shock with large scale in period 1 such that $\frac{r_0}{R} < p_{B1} < p^{DO}_{B1}$,*

   (a) bank A conducts driving out strategy and bank B is out of market;

   (b) bank B is driven out of market by aggressive competition by its competitor A even though it can earn revenue higher than on risk-free asset and thus potentially profitable.

Our result shed an important light on the welfare implication of interbank market competition, in particular for the case where a bank is out of business whereas it can make a revenue higher than depositors' outside option and its distress is temporary. Driving-out strategy is conducted by a stronger bank when it rewards higher overall profit than competitive equilibrium. This increase in overall profit comes with detriment of depositors' surplus. By definition of driving-out strategy, all depositors receive a deposit contract that gives higher net surplus, in terms of expected return net of transportation cost in the first period. However, this comes at the decrease in period-2 surplus by lower interest than the case of competitive equilibrium[12], higher transportation cost for depositors close to former location of bank B. In equilibrium, surplus loss by depositors in period 2 might be higher than additional surplus that depositors earn during the first period. Moreover, the bank that becomes monopoly does not necessarily intermediate all funds depositors retain to most profitable investment opportunity. In our model, depositors located far from the monopoly bank face higher transportation cost and given that expected return on deposit is lower than the competitive equilibrium, they may find less profitable to deposit to the bank than to take outside option (r_0). This situation can be interpreted as the one in which fund is invested in less profitable project than the bank can undertake ($p_A R$). This can generate welfare loss in economy. Overall, our theoretical analysis suggests that competition for deposits especially during crisis require a particular attention and need a close monitoring on changes in market share to know whether there exist any concern about its impact on depositors' surplus and efficient allocation of funds.

III. Data and empirical methodology

A. Data

In section III and IV, we conduct an empirical investigation on our theoretical predictions. In the analysis, we consider the spread of implicit deposit rates over the 3-month U.S. Treasury bill rate (we call it deposit spread, hereafter) as the indicator on the strategic competition.[13] Then we test whether this strategic variable has been actively used during the crisis for the purpose of increasing market share.

The data are from U.S. Call Reports provided by the Federal Reserve Bank of Chicago, which covers bank-specific information on all FDIC-insured deposits institutions on a quarterly basis. We focus on the top percentile of largest commercial banks in terms of deposit base over the period 2000-12. Our choice of banks is motivated by the two following reasons: First, we are interested especially in investigating the reason of unequal distribution of deposit inflows among large banks during the financial crisis because they were the main receivers of deposits on the aggregate level. Second, by this choice we want to minimize measurement error. It should be noted that our deposit rates as well as the market share are estimated using information reported on the consolidated bank-level. Deposit rates are measured by interest expenses on deposits over average total deposits for

[12] We can easily verify it by comparing lemma 1 and 2.

[13] Alternatively, one can use the spread of deposit rate over federal funds rate instead of that over U.S. Treasury bill rate. While we conducted robustness checks with this alternative measure, we omit to present their result in this paper given that the results were very similar.

each period. Indeed, banks may compete locally for deposits given that many banks in our sample operate in geographically separated markets and across different states. To some extent this implies that the competition indicators are subject to a measurement error, in the sense that deposit rates in one branch might differ from the rate of other branches. By using consolidated variables, we implicitly assume that their distribution is similar across branches. To reduce the possibility of an estimation bias, we concentrate our analysis on the top percentile of largest banks in the United States based on the idea that all of these banks operate on a nationwide basis. As such the impact of local shocks on our variables of interest should cancel out on average.[14]

We use the top percentile based on deposits instead of total assets for the purpose of not including large banks of which main source of funding is not deposits (but for example wholesale funds) considering that these banks have a different business model and will behave differently on the market for deposits.

B. Identification strategy and baseline model

One issue that we need to address is to isolate the use of the deposit spread with a purpose of increasing market power from other purposes. On the one hand, banks may attempt to attract more deposits for precautionary motives in the expectation that they need more liquidity in the near future, especially during or at the brink of a crisis (Acharya and Merrouche, 2013; Berrospide, 2013). On the other hand, banks facing or fearing deposit drainage may attempt to keep their depositors by increasing the deposit rate. This could be particularly the case for banks perceived as being in financial difficulty. In order to control for these precautionary and defensive motives, we follow a two-stage approach. In the first-stage, by controlling for the motives of attracting deposits, we isolate normal from abnormal changes in the deposit spread. The abnormal changes are in turn identified by the error term of the regressions on the deposit spread, *i.e.* the unexplained part of the variation in the variables of interest. We refer to the residuals as strategic overbidding. In the second stage regression, we then examine the impact of overbidding on banks' deposit market share.

Concretely, we construct the following first stage regression inspired by Acharya and Mora

[14] A possibility would be to work with the Summary of Deposits database which provides information on the location of branches and the amount of deposits per branch. While there exists a commercial database on a limited number of deposit rates across branches (Bankrate Inc), the Summary of Deposits database reports the amount of deposits only in annual frequency whereas our data set is quarterly. We believe, however, that using this data could be an interesting extension of our present work.

(2015):

$$
\begin{aligned}
Y_{it} \;=\; & \alpha_0 + \alpha_1 \times \text{liquidity risk}_{i,t-1} + \alpha_2 \times \text{crisis}_t \times \text{liquidity risk}_{i,t-1} \\
& + \alpha_3 \times \text{solvency}_{i,t-1} + \alpha_4 \times \text{crisis}_t \times \text{solvency}_{i,t-1} \\
& + \alpha_5 \times \text{time fixed effects}_t + \alpha_6 \times \text{bank fixed effects}_i + \varepsilon_{it}
\end{aligned} \tag{16}
$$

where Y_{it} refers to the deposit spread measured by the difference between implicit deposit rates and the 3-month U.S. T-bill rate (on core and large deposits, respectively) of bank i in quarter t. As measures of liquidity risk we use unused commitments, net wholesale funding computed by wholesale funds minus liquid assets (all as a percentage of assets). Banks with higher liquidity risk may have stronger incentives to actively compete for deposits by increasing deposit demand. The solvency measures include equity (over assets) and mortgages (over loans). We control for the size of banks (logarithm of assets), as well as the degree of competition and market interest rate by including the average deposit rate weighted by the deposit base for quarter t. They control for both deposit demand and supply factors.

To account for possible changes in the relationship between the variables during the crisis, we interact the liquidity and solvency measures as well as the other control variables with a dummy variable *Crisis*. Gatev and Strahan (2006) demonstrated that the banking system typically experiences inflows of deposits during a financial turmoil and it could thus be that it is easier for banks to attract new deposits compared to normal times. In contrast, Acharya and Mora (2015) showed that the funding advantage of banks broke up during the early stage of the 2007-09 financial crisis, and that banks reacted by increasing deposit rates. To capture this, we use two *Crisis* dummies: *Crisis1* is equal to one during 2007q3 -2008q2 and zero otherwise and *Crisis2* is equal to one during 2008q3-2009q2 and zero otherwise. We include as well time fixed effects to control for common shocks on the national level. As suggested by the Hausman test, the regressions are estimated using the fixed effects estimator, which allows to control for other unobserved and time-invariant bank fixed effects possibly omitted. Finally, we lag the independent variables by one period (quarter) to reduce the potential for endogeneity and simultaneous determination.

In the second stage regression, we investigate whether banks that strategically overbid also attracted more deposits during the financial crisis than banks that did not. To this purpose, we regress banks' market share (deposits of banks divided by the system's deposits) on the indicator of overbidding obtained from the first stage regression and a number of control variables. The econometric model can be summarized as follows:

$$
\begin{aligned}
MS_{it} &= \beta_0 + \beta_1 \times \text{overbidding}_{i,t-1} \\
&\quad + \beta_2 \times \text{crisis}_t \times \text{overbidding}_{i,t-1} \\
&\quad + \beta_3 \times \text{bank-level controls}_{i,t-1} + \beta_4 \times \text{crisis}_t \times \text{bank level controls}_{i,t-1} \\
&\quad + \beta_5 \times \text{macro controls}_{i,t-1} + \beta_6 \times \text{crisis}_t \times \text{macro controls}_{i,t-1} \\
&\quad + \beta_7 \times \text{bank fixed effects}_i + \varepsilon_{it}
\end{aligned} \tag{17}
$$

where MS_{it} stands for the deposit market share of bank i at time t. Overbidding refers to the abnormal changes in the implicit deposit spread obtained during the first-stage. We include a number of other potential determinants of the deposit market share on the bank-and macro-level. As in the first-stage, we lag all independent variables by one quarter and interact them with the two dummy variables *Crisis1* and *Crisis2*. The regressions are estimated by the fixed-effects estimator as suggested by the Hausman test, which may capture possibly omitted bank-specific fixed effects.

As bank-specific control variables, we include a number of potentially important determinants of deposit flows, namely, bank risk and profitability indicators. More specifically, we include banks' capital ratio, non-performing loan ratio (NPL), Z-Score and bank size.[15] We control for changes in market shares resulted from mergers and acquisitions (*MergyDummy*) as well as for failures or acquisitions by other banks (*LeaveDummy*). The macroeconomic control variables include real GDP growth, house price growth and the 3-month U.S. T-bill rate. In our baseline model we conduct the regression with two specifications: the first one with the macroeconomic control variables and the second one with time-fixed effects. In October 2008, the FDIC increased the limit for deposit insurance from USD 100,000 to USD 250,000. We control for its possible impact on the deposit market by adding a dummy variable for 2008q4 in the specification without time fixed effects. Finally, we control for the deposit market conditions by including the Herfindahl-Hirschman Index (HHI) for the aggregate deposit market in the U.S considering that the relationship between our overbidding measure and market share could vary upon the condition in deposit market.

Our theoretical model predicts that banks might have incentives to compete for deposits by increasing deposit spreads, particularly so during a financial crisis. In terms of the regression framework, this would imply that the coefficient β_2 associated with the interaction terms between the overbidding indicator and the crisis dummies is significantly positive.

We conduct the regression separately for two deposits segments, core deposits and large time deposits expecting that the behavior of banks and of depositors will be different in each market. Core deposits are the sum of checking, savings and small time deposits (less than USD 100,000)

[15] Following Boyd and Graham (1986), DeYoung and Torna (2013), bank Z-score is calculated by ${(Capital\ Ratio + \mu(ROA))}/{\sigma(ROA)}$ where $\mu(ROA)$ and $\sigma(ROA)$ are respectively mean and standard deviation of ROA over 12 quarters.

whereas large time deposit are deposits with more than USD 100,000. Core deposits are mainly protected by deposit insurance and are considered to be banks' most stable source of funding (Federal Deposit Insurance Corporation 2011), whereas large time deposits are not insured (at least before October 2008 and then only partially to the limit of USD 250,000) and they work more as a part of wholesale funding. Principal players in this deposit segment are institutional and corporate cash investors rather than households. We therefore expect that the impact of competition for deposits during the crisis would be more pronounced in the core deposit segment. Accordingly, it is expected that our coefficients of interest would be more significant for core deposits. The descriptive statistics of the main variables are reported in Table 1. Table 2 and 3 represent the correlation coefficients for main independent variables in the first- and the second-stage regressions, respectively.

[Table 1, 2 and 3 around here]

IV. Empirical results and further analysis

A. Main results

The estimation results of the first-stage are reported in Table 4 and those of the second-stage in Table 5 for the baseline model. Standard errors are clustered at the bank level. As mentioned before, the residuals from the first-stage serve as proxies for overbidding and are employed in the second-stage on the determinants of market shares. Considering the results of the second-stage regression (table 5), we observe that a higher overbidding during normal times is not associated with higher market shares. Interestingly, overbidding is significant during the second period of the crisis (2008q3 - 2009q2) suggesting that a higher abnormal deposit spread is followed by significantly higher market shares. In other words, after controlling for movements in the deposit rates due to liquidity and solvency risks, there exist banks which have been successful in attracting deposits with abnormal deposit spreads. According to our estimation, 1 percentage point of marginal strategic overbidding is associated with increases in the core deposit market share in the range from 0.183 and 0.186%.

[Table 4 and 5 around here]

The relationship between abnormal overbidding and market shares during the second phase of the crisis is only significant in the core deposit segment, but not in the large time deposit segment. This result is consistent with our expectation that banks have more actively competed for core deposits and have been more successful in attracting them. It could be that banks during the crisis have attempted to attract deposits from banks (perceived as being) in difficulty, looking for a safe shelter with better remuneration. It could be that more stable banks have competed for these funds by offering attractive terms (deposit rate) as well as safety offered by deposit insurance. The depositors (especially with uninsured deposits) in distressed banks might have withdrawn their deposits in an attempt to deposit them in other banks converting them into core deposits. Even if overbidding is costly in the short-term, it could be a good opportunity for banks to enlarge their stable funding sources since depositors are (at least partially) captive in the future to the extent that switching banks is costly, especially in the case of checking deposits with which households link most of their payment services.

In October 2008, the FDIC increased the deposit insurance limit, which might have affected the behavior of depositors. To be sure that our results are not affected this, we added a dummy variable for the fourth quarter of 2008 in the specification without time fixed effects (which should capture any common shocks to the banking industry).

The abnormal overbidding for core deposits has been followed by increases in market shares only during the late stage of the crisis, not during the early stage. This is presumably because in the early stage of the crisis, there has been too high uncertainty about the banking system as a whole, and fundamentally stable banks with higher remuneration of deposits might not have been in the position to attract additional deposits. This is consistent with the findings in Acharya and Mora (2015), according to which the banking system as whole was at the center of the crisis and their attempt to attract deposits by offering higher rates was not successful.

We control for alternative factors such as solvency and profitability of banks which might have played a role in attracting deposits during the crisis (market discipline). These are the capital ratio, non-performing loans as well as the Z-score. We find that higher Z-scores have been associated with higher market shares in normal times whereas we could not find any significant evidence that these variables have contributed to even higher market shares during the crisis.

B. Which banks are engaged in overbidding successfully

Even though we have chosen the top percentile banks in terms of deposits, all banks in our sample are part of largest banks in terms of assets. More specifically, they all had more than USD 10 billion in total assets. It is interesting to test whether banks engaged successfully in overbidding depending on their asset size. We may expect that very large banks are seen as too-big-to-fail and they could have benefited from this implicit guarantee without a need of overbidding. As such, they might have behaved differently. Therefore, we brake down our sample into two sub-samples upon asset size (banks with more than USD 50 billion of assets and the other with less) and conduct the regression for each sub-sample. The results are shown in Table 6. Interestingly we observe that the coefficient of the interaction term between overbidding and the dummy for the second crisis period is still (and even more) significant for the sub-sample of banks with less than USD 50 billion of total assets whereas this coefficient is not significant for the sub-sample of banks larger than USD

50 billion.

This result suggests that our results are not driven by the largest banks in our sample but rather by the lower top largest banks. One possible explanation could be that upper top largest banks have benefited from implicit guarantees due to their distinguished size without a need for overbidding, while the lower top largest banks heightened competition through abnormal remuneration of deposits.

[Table 6 around here]

C. Robustness checks

We used market share as a dependent variable in our baseline model. We believe that market share is an adequate variable to focus exclusively on the impact of deposit market competition across banks. Market share was computed by deposits over total deposits in banking system, which allows us to capture competition for deposits (or savings more generally) between the commercial banking sector and other financial sectors. In particular, the existing literature argued that the banking sector as a whole has attracted more deposits during the crisis since it is viewed as a safe haven (Gatev and Strahan, 2006), but this was not the case during the first phase of the 2007-09 crisis (Acharya and Mora, 2015).

It would thus be interesting to test if overbidding had an effect on deposit flows themselves. For this purpose, we replace our dependent variable, market share, by (i) the logarithm of deposits and (ii) deposits to total assets. Note that in specifications (i), the coefficient of interaction term of overbidding with the dummy variables can be interpreted as the marginal deposit growth in response to a 1 percentage point increase of abnormal overbidding. As can be seen in Table 7, we obtain similar results.

[Table 7 around here]

Our overbidding indicator is not directly observable but a proxy we inferred for the first stage regression. It may thus exhibit a measurement error that might bias our results. Given this possible measurement error, we conduct an alternative regression as a robustness check. For this purpose, we substitute the decile number of overbidding for our overbidding indicator in the second stage regression. Our coefficients of interest are still significant (less in the case of the specification with macro controls), see Table 8.

[Table 8 around here]

We conducted several additional robustness checks: using HHI for the degree of competition in the first stage regression instead of weighted average deposit rate and replacing the 3-month T-bill rate by federal funds rate. We obtain similar results as in our baseline model.

V. Conclusion

The experience with the recent financial crisis in the United States and its repercussions on the real economy have changed the landscape of the banking sector in many aspects. One particular aspect, studied in this paper, is the increase in the degree of bank concentration in the deposit market. As highlighted by our theoretical model on banking competition, banks have incentives in engaging in strategic behavior in the market for deposits, by increasing deposits rates above normal levels, especially when the banking sector is hit by a large and adverse financial shock. Banks not hit by the crisis might take advantage of the financial turmoil and drive-out liquidity-constrained banks in an attempt to increase future rents associated with higher market power.

The econometric exercise carried out to test our theoretical predictions within the US banking industry confirms our intuition. After controlling for banks' liquidity needs and solvency position, we derive in a first stage abnormal changes in implicit deposit spreads. Using these proxies for strategic (price and non-price) competition on the deposit market, we find evidence that banks with abnormally high deposit rates during the financial crisis have seen their market shares increasing.

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Table 1: Descriptive statistics

	Mean	Std. Dev.	25th percentile	Median	75th percentile	Obs.
Total assets (billion USD)	117.262	255.411	19.710	40.447	85.053	2959
Deposits, all (billion USD)	59.621	121.625	12.172	21.754	47.447	2959
Deposits, core (billion USD)	52.386	111.158	9.997	18.123	41.599	2959
Deposits, large (billion USD)	7.235	13.476	1.052	2.770	7.233	2959
Total deposits to total assets (%)	61.128	18.528	51.848	64.254	74.376	2959
Market share, all (%)	0.990	1.812	0.220	0.420	0.800	2959
Market share, core (%)	1.010	1.897	0.210	0.415	0.846	2959
Market share, large (%)	0.538	0.939	0.087	0.208	0.553	2959
Deposit rate, all (%)	1.762	1.210	0.824	1.545	2.503	2959
Deposit rate, core (%)	1.559	1.116	0.713	1.351	2.230	2959
Deposit rate, large (%)	3.014	1.563	1.787	2.952	4.246	2930
Spread over 3-month T-bill rate, all (%)	-0.026	1.282	-0.699	0.178	0.642	2959
Spread over 3-month T-bill rate, core (%)	-0.228	1.278	-0.872	0.056	0.481	2959
Spread over 3-month T-bill rate, large (%)	1.217	1.420	0.268	1.209	2.112	2930
Unused commitments to loans (%)	53.155	23.913	34.142	51.584	80.884	2959
Net wholesale funding ratio (%)	-0.652	18.576	-10.779	0.762	10.456	2959
Mortgages to total assets (%)	31.182	18.507	18.622	32.871	45.109	2959
Book capital ratio (%)	10.913	5.083	7.809	9.494	12.399	2959
NPL to total assets (%)	1.086	1.209	0.354	0.673	1.383	2959
Z-Score, mean over 12 quarters	130.730	121.664	50.060	91.861	167.662	2959
HHI, overall deposits market	0.026	0.009	0.017	0.026	0.033	2959

Note: The summary statistics are based on 89 banks over the period 2000-12. Core deposits are the sum of transaction, saving and time deposits of less than USD 100,000. Large time deposits are deposits with more than USD 100,000. Market shares are calculated as bank deposits divided by the banking sector's deposits. Spreads are derived from the implicit deposit rate (interest expenses on deposits divided by deposits). The net wholesale funding ratio is wholesale funds minus liquid assets (cash, federal funds sold, reverse repos, securities excluding MBS/ABS securities) divided by total assets. Z-score is calculated by $(Capital\,Ratio+\mu(ROA))/\sigma(ROA)$ where $\mu(ROA)$ and $\sigma(ROA)$ are respectively mean and standard deviation of ROA over 12 quarters. Sources: US Call reports.

Table 2: Pairwise correlation coefficients for the 1st stage independent variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Unused commitments over total loans	1							
(2) Net wholesale funding ratio	0.0743***	1						
(3) Mortgage over total assets	-0.678***	0.126***	1					
(4) Book capital ratio	0.0894***	0.163***	-0.206***	1				
(5) Average deposit rate, core (weighted by deposits)	0.0311	0.171***	0.0429*	-0.0875***	1			
(6) Average deposit rate, large (weighted by deposits)	0.0375*	0.179***	0.0505**	-0.0854***	0.993***	1		
(7) HHI for overall deposits market	0.00898	-0.0926***	-0.0166	0.174***	-0.544***	-0.559***	1	
(8) Size (log(total assets))	0.352***	0.269***	-0.168***	-0.0166	-0.165***	-0.166***	0.308***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Pairwise correlation coefficient for 2nd stage independent variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Overbidding, residual of spread on core deposits	1						
(2) Overbidding, residual of spread on large time deposits	0.234***	1					
(3) Book capital ratio	-0.0179	-0.0373*	1				
(4) NPL to total assets	0.0782***	0.0153	0.0839***	1			
(5) Z-Score (mean over 12 quarters)	-0.0210	0.0257	-0.0873***	-0.295***	1		
(6) size	0.0212	0.0115	-0.0267	0.150***	-0.0517**	1	
(7) HHI, all	0.00972	0.000444	0.171***	0.426***	-0.120***	0.305***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Baseline model: 1st stage regression

	(1) Spread, core	(2) Spread, large
L.Unused commitments	-0.005**	0.007**
	(0.002)	(0.003)
L.Unused commitments × Crisis1	-0.001	-0.004
	(0.004)	(0.005)
L.Unused commitments × Crisis2	-0.006	-0.006
	(0.005)	(0.006)
L.Net wholesale funding	-0.008*	-0.006
	(0.004)	(0.004)
L.Net wholesale funding × Crisis1	0.001	-0.006
	(0.007)	(0.007)
L.Net wholesale funding × Crisis2	0.002	0.013*
	(0.003)	(0.007)
L.Mortgage to total assets	0.001	-0.002
	(0.004)	(0.005)
L.Mortgage to total assets × Crisis1	0.000	0.015**
	(0.008)	(0.007)
L.Mortgage to total assets × Crisis2	0.006	-0.001
	(0.007)	(0.008)
L.Capital Ratio	0.004	-0.014
	(0.012)	(0.015)
L.Capital Ratio × Crisis1	-0.003	0.034**
	(0.034)	(0.016)
L.Capital Ratio × Crisis2	-0.035*	-0.028
	(0.018)	(0.020)
L.size	0.090	0.140
	(0.153)	(0.137)
L.size × Crisis1	-0.029	0.122
	(0.065)	(0.090)
L.size × Crisis2	-0.105	-0.204**
	(0.065)	(0.089)
L.Ave. deposits rate, core (weighted by deposits)	-0.081	
	(0.052)	
L.Ave. deposits rate, core × Crisis1	0.250	
	(0.599)	
L.Ave. deposits rate, core × Crisis2	2.462**	
	(1.109)	
L.Ave. deposits rate, large (weighted by deposits)		0.099**
		(0.048)
L.Ave. deposits rate, large × Crisis1		-0.553
		(0.407)
L.Ave. deposits rate, large × Crisis2		2.148***
		(0.745)
Constant	-1.181	-1.743
	(2.872)	(2.577)
Time Fixed Effects	Yes	Yes
Observations	2959	2930
Banks	89	89
R^2	0.61	0.36

Note: The dependent variables, the spread for core/large-time deposits, are measured by the difference between the implicit interest rate on core/large-time deposits and the 3-month US T-bill rate. The sample period is 2000-12. The regressions are estimated by the fixed effects estimator. Standard errors (in parentheses) are clustered at the bank-level. R^2 is overall coefficient of determination. ***,**,* indicate significance on the 1%, 5%, and 10% level.

Table 5: Baseline model: 2nd stage regression

	(1) market share, core	(2) market share, core	(3) market share, large	(4) market share, large
L.Overbidding, core	-0.021	-0.023		
	(0.032)	(0.032)		
L.Overbidding, core × Crisis1	0.079	0.081		
	(0.078)	(0.077)		
L.Overbidding, core × Crisis2	0.183**	0.186**		
	(0.079)	(0.085)		
L.Overbidding, large			-0.001	-0.002
			(0.026)	(0.025)
L.Overbidding, large × Crisis1			0.033	0.031
			(0.026)	(0.027)
L.Overbidding, large × Crisis2			-0.064	-0.060
			(0.053)	(0.048)
Controls				
L.Capital Ratio	0.012	0.011	0.007	0.005
	(0.007)	(0.007)	(0.005)	(0.005)
L.Capital Ratio × Crisis1	-0.010	-0.011	-0.003	-0.001
	(0.008)	(0.008)	(0.007)	(0.006)
L.Capital Ratio × Crisis2	-0.021	-0.019	-0.011	-0.005
	(0.015)	(0.013)	(0.011)	(0.007)
L.NPL to total assets	0.113	0.121	-0.029	0.005
	(0.083)	(0.095)	(0.032)	(0.034)
L.NPL to total assets × Crisis1	-0.044	-0.048	-0.060	-0.055
	(0.068)	(0.075)	(0.064)	(0.079)
L.NPL to total assets × Crisis2	-0.110	-0.102	-0.050	-0.038
	(0.068)	(0.083)	(0.040)	(0.049)
L.Z-Score, mean over 12 quarters	0.103**	0.099**	0.045**	0.032*
	(0.048)	(0.047)	(0.020)	(0.019)
L.Z-Score × Crisis1	-0.053	-0.052	-0.013	0.007
	(0.033)	(0.033)	(0.018)	(0.025)
L.Z-Score × Crisis2	-0.042	-0.016	-0.043	0.002
	(0.038)	(0.058)	(0.030)	(0.037)
L.size	0.610***	0.620***	0.241***	0.264***
	(0.191)	(0.210)	(0.054)	(0.058)
L.size × Crisis1	0.013*	-0.004	-0.002	0.036
	(0.006)	(0.055)	(0.006)	(0.063)
L.size × Crisis2	0.021*	0.097	0.015	0.129
	(0.012)	(0.106)	(0.012)	(0.094)
Leave Dummy	-0.123*	-0.120*	-0.053*	-0.052
	(0.064)	(0.063)	(0.030)	(0.033)
Merge Dummy	0.200**	0.200**	0.054*	0.054**
	(0.084)	(0.087)	(0.027)	(0.026)
Macro controls	Yes	No	Yes	No
Time Fixed Effect	No	Yes	No	Yes
Observations	2870	2870	2844	2844
Banks	89	89	89	89
R^2	0.57	0.58	0.49	0.52

Note: Overbidding is measured by residual terms from the 1st stage regression. The sample period is 2000-12. The regressions are estimated by the fixed effects estimator. Standard errors (in parentheses) are clustered at the bank-level. R^2 is overall coefficient of determination. ***,**,* indicate significance on the 1%, 5%, and 10% level. Full regression result with macro control variable in detail is relegated in Appendix, Table A1.

Table 6: Sub-sample regression upon size of banks

Panel A: Regression for banks with total assets < USD 50 billions				
	(1)	(2)	(3)	(4)
	market share, core	market share, core	market share, large	market share, large
L.Overbidding, core	0.001	0.002		
	(0.012)	(0.011)		
L.Overbidding, core × Crisis1	0.008	0.006		
	(0.015)	(0.014)		
L.Overbidding, core × Crisis2	0.081***	0.084***		
	(0.026)	(0.026)		
L.Overbidding, large			0.005	0.005
			(0.010)	(0.010)
L.Overbidding, large × Crisis1			0.002	0.000
			(0.013)	(0.012)
L.Overbidding, large × Crisis2			-0.003	-0.001
			(0.010)	(0.009)
Controls	Yes	Yes	Yes	Yes
Macro Controls	Yes	No	Yes	No
Time Fixed Effect	No	Yes	No	Yes
Observations	1579	1579	1564	1564
Banks	52	52	52	52
R^2	0.56	0.56	0.18	0.23

Panel B: Regression for banks with total assets > USD 50 billions				
	(1)	(2)	(3)	(4)
	market share, core	market share, core	market share, large	market share, large
L.Overbidding, core	0.118	0.102		
	(0.090)	(0.087)		
L.Overbidding, core × Crisis1	-0.016	0.001		
	(0.131)	(0.131)		
L.Overbidding, core × Crisis2	-0.033	-0.038		
	(0.153)	(0.163)		
L.Overbidding, large			-0.025	-0.023
			(0.055)	(0.052)
L.Overbidding, large × Crisis1			0.089	0.095*
			(0.055)	(0.050)
L.Overbidding, large × Crisis2			-0.064	-0.068
			(0.079)	(0.064)
Controls	Yes	Yes	Yes	Yes
Macro Controls	Yes	No	Yes	No
Time Fixed Effect	No	Yes	No	Yes
Observations	1286	1286	1275	1275
Banks	36	36	36	36
R^2	0.71	0.73	0.47	0.54

Standard errors in parentheses

Notes: 2001-2012. Overbidding is measured by residual terms of 1st stage regression with spread. Standard errors are clustered by bank.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Regression with deposits as dependent variable

Panel A: log(Deposits) as dependent variable

	(1)	(2)	(3)	(4)
	log(Deposits), core	log(Deposits), core	log(Deposits), large	log(Deposits), large
L.Overbidding, core	-0.001	0.002		
	(0.075)	(0.074)		
L.Overbidding, core × Crisis1	0.281	0.278		
	(0.196)	(0.188)		
L.Overbidding, core × Crisis2	0.446*	0.446**		
	(0.225)	(0.216)		
L.Overbidding, large			0.081	0.081*
			(0.049)	(0.048)
L.Overbidding, large × Crisis1			-0.003	-0.010
			(0.060)	(0.061)
L.Overbidding, large × Crisis2			-0.138	-0.143
			(0.095)	(0.096)
Controls	Yes	Yes	Yes	Yes
Macro Controls	Yes	No	Yes	No
Time Fixed Effect	No	Yes	No	Yes
Observations	2870	2870	2829	2829
Banks	89	89	89	89
R^2	0.67	0.67	0.50	0.51

Panel B: Deposit to total assets as dependent variable

	(1)	(2)	(3)	(4)
	Deposits/TA, core	Deposits/TA, core	Deposits/TA, large	Deposits/TA, large
L.Overbidding, core	0.004	0.004		
	(0.010)	(0.010)		
L.Overbidding, core × Crisis1	0.030	0.030		
	(0.024)	(0.024)		
L.Overbidding, core × Crisis2	0.081**	0.082**		
	(0.039)	(0.037)		
L.Overbidding, large			0.006	0.006
			(0.004)	(0.004)
L.Overbidding, large × Crisis1			0.007	0.007
			(0.006)	(0.006)
L.Overbidding, large × Crisis2			-0.011*	-0.010*
			(0.006)	(0.006)
Controls	Yes	Yes	Yes	Yes
Macro Controls	Yes	No	Yes	No
Time Fixed Effect	No	Yes	No	Yes
Observations	2870	2870	2844	2844
Banks	89	89	89	89
R^2	0.13	0.15	0.044	0.045

Standard errors in parentheses

Notes: 2001-2012. Overbidding is measured by residual terms of 1st stage regression with spread. Standard errors are clustered by bank.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Decile of overbidding as a measure of overbidding: 2nd stage regression

	(1) market share, core	(2) market share, core	(3) market share, large	(4) market share, large
L.Overbidding, core	-0.001	0.000		
	(0.008)	(0.009)		
L.Overbidding, core × Crisis1	0.009	-0.008		
	(0.015)	(0.021)		
L.Overbidding, core × Crisis2	0.031**	0.026*		
	(0.013)	(0.014)		
L.Overbidding, large			-0.004	-0.004
			(0.008)	(0.007)
L.Overbidding, large × Crisis1			0.008	0.013
			(0.010)	(0.012)
L.Overbidding, large × Crisis2			-0.001	-0.007
			(0.013)	(0.015)
Controls	Yes	Yes	Yes	Yes
Macro Controls	Yes	No	Yes	No
Time Fixed Effect	No	Yes	No	Yes
Observations	2870	2870	2844	2844
Banks	89	89	89	89
R^2	0.11	0.11	0.097	0.12

Standard errors in parentheses

Notes: 2001-2012. Standard errors are clustered by bank.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix

Table A1: Baseline model: 2nd stage regression in detail

	(1)	(2)	(3)	(4)
	market share, core	market share, core	market share, large	market share, large
L.Overbidding, core	-0.021	-0.023		
	(0.032)	(0.032)		
L.Overbidding, core × Crisis1	0.079	0.081		
	(0.078)	(0.077)		
L.Overbidding, core × Crisis2	0.183**	0.186**		
	(0.079)	(0.085)		
L.Overbidding, large			-0.001	-0.002
			(0.026)	(0.025)
L.Overbidding, large × Crisis1			0.033	0.031
			(0.026)	(0.027)
L.Overbidding, large × Crisis2			-0.064	-0.060
			(0.053)	(0.048)
Controls				
L.Capital Ratio	0.012	0.011	0.007	0.005
	(0.007)	(0.007)	(0.005)	(0.005)
L.Capital Ratio × Crisis1	-0.010	-0.011	-0.003	-0.001
	(0.008)	(0.008)	(0.007)	(0.006)
L.Capital Ratio × Crisis2	-0.021	-0.019	-0.011	-0.005
	(0.015)	(0.013)	(0.011)	(0.007)
L.NPL to total assets	0.113	0.121	-0.029	0.005
	(0.083)	(0.095)	(0.032)	(0.034)
L.NPL to total assets × Crisis1	-0.044	-0.048	-0.060	-0.055
	(0.068)	(0.075)	(0.064)	(0.079)
L.NPL to total assets × Crisis2	-0.110	-0.102	-0.050	-0.038
	(0.068)	(0.083)	(0.040)	(0.049)
L.Z-Score, mean over 12 quarters	0.103**	0.099**	0.045**	0.032*
	(0.048)	(0.047)	(0.020)	(0.019)
L.Z-Score × Crisis1	-0.053	-0.052	-0.013	0.007
	(0.033)	(0.033)	(0.018)	(0.025)
L.Z-Score × Crisis2	-0.042	-0.016	-0.043	0.002
	(0.038)	(0.058)	(0.030)	(0.037)
L.size	0.610***	0.620***	0.241***	0.264***
	(0.191)	(0.210)	(0.054)	(0.058)
L.size × Crisis1	0.013*	-0.004	-0.002	0.036
	(0.006)	(0.055)	(0.006)	(0.063)
L.size × Crisis2	0.021*	0.097	0.015	0.129
	(0.012)	(0.106)	(0.012)	(0.094)
Leave Dummy	-0.123*	-0.120*	-0.053*	-0.052
	(0.064)	(0.063)	(0.030)	(0.033)
Merge Dummy	0.200**	0.200**	0.054*	0.054**
	(0.084)	(0.087)	(0.027)	(0.026)
HHI, all	0.064	-0.092	-0.090*	0.060
	(0.075)	(0.095)	(0.049)	(0.061)
housing price	-0.002		-0.008***	
	(0.002)		(0.002)	
log(gdp), 2009 constant	-1.021		3.426***	
	(0.769)		(1.155)	
3M T-bill rate	0.019		0.031***	
	(0.012)		(0.012)	
2008q4	-0.025		0.051	
	(0.028)		(0.041)	
Constant	-0.284	-10.031***	-35.183***	-4.219***
	(6.832)	(3.635)	(10.699)	(1.010)
Time Fixed Effect	No	Yes	No	Yes
Observations	2870	2870	2844	2844
Banks	89	89	89	89
R^2	0.57	0.58	0.49	0.52