Emergency liquidity facilities, signaling, and funding costs*

Céline Gauthier † Alfred Lehar ‡ Hector Perez-Saiz § Moez Souissi ¶

October 29, 2015

Abstract

In the months preceeding the failure of Lehman Brothers in September 2008, banks were willing to pay a premium over the Federal Reserve's discount window (DW) rate to participate in the much less flexible Term Auction Facility (TAF). We empirically test the predictions of a new signaling model that offers a rationale for offering two different liquidity facilities. In our model illiquid yet solvent banks need to pay a high cost to access the TAF as a way to signal their quality, in exchange for more favorable funding in the future. Less solvent banks access the less costly and more flexible DW in case they experience an unexpected run, paying a higher future funding cost. The existence of two facilities with different characteristics allowed banks to signal their level of solvency, which helped decreasing asymmetric information during the crisis. Using recently disclosed data on access to these facilities, we provide evidence consistent with these results. Banks that accessed TAF in 2008 paid approximately 31 basis points less in the interbank lending market in 2010 and were perceived as less risky than banks that accessed the DW. Our results can contribute to a better design of liquidity facilities during a financial crisis.

JEL classification: G21, G28, G01.

Keywords: Discount window, TAF, funding cost, signaling.

*This article was previously entitled "Why one facility does not fit all? Flexibility and signalling in the Discount Window and TAF". We want to thank Hongyu Xiao for excellent research assistance, and we also want to thank for comments and suggestions Jason Allen, Allen Berger, James Chapman, Evren Damar, Scott Hendry, Randall Morck, Teodora Paligorova, Denis Sosyura, Gustavo Suarez and participants at seminars at the Bank of Canada, the Canadian Economics Association (2013), Financial Management Association (2014), International Monetary Fund, Midwest Finance (2014) and Northern Finance (2013). Any opinions and conclusions expressed herein are those of the authors and do not necessarily represent the views of the Bank of Canada or the International Monetary Fund.

†Université du Québec. 283 Alexandre-Taché, Gatineau, Quebec, Canada. Celine.Gauthier@uqo.ca

‡University of Calgary, 2500 University Drive NW, Calgary, Alberta, Canada. alehar@ucalgary.ca

§Bank of Canada, 234 Laurier avenue, Ottawa, Ontario, Canada. hperezsaiz@bankofcanada.ca

¶International Monetary Fund, 700 19th St NW, Washington DC, USA. MSouissi@imf.org

1 Introduction

The role of central banks as liquidity providers has been a controversial topic at least since Bagehot (1878). During the recent financial crisis, many solvent banks that experienced a liquidity crunch shied away from using the discount window (DW), the main liquidity facility set by the Federal Reserve to help banks in that very situation. Instead, at the height of the crisis (the failure of Lehman Brothers) some banks were willing to pay up to 150 basis points more (equivalent to \$172.6 million additional cost[1]) in an alternative facility, the Term Auction Facility (TAF) which had worse and less flexible lending terms in all dimensions (e.g. loan maturity or availability of funds) than the DW. However, banks that used TAF rather than the DW were able to have access to cheaper external funding in the period after the failure of Lehman.[2] The explanation we pursue in this paper is that the existence of two liquidity facilities with different characteristics allowed banks to signal their level of solvency, which helped decreasing asymmetric information, potentially preventing the failure of financial markets. As a consequence, solvent banks bid aggressively in the TAF which resulted in lower post-crisis funding cost. In this paper we propose a theoretical model that explains this trade-off and empirically analyze its predictions.

We first propose a signaling model to explain the incentives of banks to use these two facilities. The lower flexibility of the TAF compared to the DW makes the TAF more costly and hence allows banks to send a credible signal to the market. The difference flexibility is the key feature that allows for a separating equilibrium in our model. Specifically we assume that banks need to access a liquidity facility because of a random liquidity shock or because of a "run" caused by concerns about their solvency. Banks can anticipate whether they will be hit by a liquidity shock, but runs come as a surprise to them. While good banks experience only the former, bad banks can be hit by both types of shocks. In the separating equilibrium, good banks that expect a liquidity shock will pay the higher rate to access the less flexible TAF facility to signal that they do not need the flexibility of the DW to respond to sudden runs. TAF cannot be accessed instantly so bad banks

[1] See Bernanke (2009). The largest difference between the TAF auctions and the DW was 150 basis points, which corresponds to the TAF auction of September 22, 2008. Given that the amount offered in the auction was \$150 billion of loans of 28 day term, this represents approximately a difference of \$172.6 million in funding cost compared to the DW.

[2] We estimate annual savings between \$82.9 million when considering interbank borrowing, and \$1,323 million when considering funding costs for total liabilities.

do not use the TAF in the hope not to experience a run, but they need the flexibility of the DW (which can be accessed any time) in the case they eventually do experience a run. The funding markets thus infer that banks that access the TAF are of better quality than banks drawing on the DW and they price subsequent funding according to these updated beliefs.

Our empirical analysis tests the predictions of this model. We use regression analysis with bank-level fixed effects to compare funding costs for different types of instruments before and after the height of the financial crisis for banks that used the DW, TAF or none of these facilities. We find that banks that used the TAF to borrow funds at the height of the crisis have lower post crisis total funding costs (in year 2010) than banks that drew from the DW. This difference is about 7 basis points in total funding cost, and 23 basis points for rates paid in the interbank lending market. Additionally, this difference in funding cost is larger for banks that had a more intense usage of the TAF (relative to their size), and for banks that were substantially riskier than the rest of the banks.

To confirm the robustness of our results, we extend our econometric model in two ways. We first use a matching estimator that allows us to control for non linearities and selection effects on observables. We then use an instrument to control for potential endogeneity problems of the decision of using TAF or the DW. Membership of banks in the board of the Federal Reserve (henceforth the Fed) is a variable that should be correlated with the decision of using Fed liquidity facilities, but should not be directly related to the funding cost, making it a valid instrument.[3] In both cases, we confirm our initial findings.[4]

In addition to our main finding that banks accessing the TAF enjoy lower funding costs post crisis we find additional evidence about the higher solvency of banks that used TAF. Consistent with the predictions of our model, the majority of U.S. banks that failed during the crisis (most of them in 2009 and subsequent years) were mainly borrowing from the DW during the pre-Lehman period and only a few of them used the TAF as their main source of liquidity from the Fed.

[3] This instrument has been already used by Bayazitova and Shivdasani (2012), Li (2013), and Berger and Roman (2014) to instrument the decision of banks to participate in the Troubled Asset Relief Program (TARP).

[4] Interestingly, we find that banks that are members of the board are less likely to use these facilities, which could be due to a desire to avoid a conflict of interests since these banks have a direct role as supervisors and overseers of the Reserve Banks that manage these facilities.

We also study how the use of DW or TAF affects the structure of funding. We observe that TAF banks rely more on savings and insured deposits, but they do not pay significantly different rates than DW banks on these deposit accounts. Depositors seem to be less price elastic, which is particularly true for insured deposits, which provides customers with a safe place to keep their savings. However, deposits tend to be cheaper than other sources of funding. The freeze of alternative funding markets led to an increase in the use of deposits as a source of funding, which has been well documented in the literature (Gatev and Strahan, 2006; Cornett *et al.*, 2011). Compared to DW banks, TAF banks were able to expand more their usage of these deposits without significantly changing the rates paid.

Our results have relevant implications for the design of liquidity facilities because it gives a rationale for providing two facilities with distinct features. The reduced flexibility of the TAF is less costly for good banks than for bad banks and can therefore serve as a credible signal for good banks to show their quality to the market.[5] During the peak of the crisis, as signaling becomes more important, good quality banks are willing to pay a much higher rate for more stringent lending terms to signal their quality. This may have helped decreasing the level of uncertainty and asymmetric information during the crisis, and may have prevented the failure of financial markets.[6]

Our findings contribute to the extensive literature on the Lender-of-Last Resort (LOLR) role that central banks can play in times of systemic distress. In his classic paper, Bagehot (1878) argued that central banks should provide liquidity support to any institution willing to offer good collateral but at a penalty rate. Rochet and Vives (2004) and Diamond and Rajan (2005) provide a theoretical foundation for Bagehot's classical doctrine, suggesting that in times of financial stress, it is hard to distinguish between insolvent and solvent but illiquid banks, and so that the access to LOLR facilities needs to be unconditional on any criteria for a bank's solvency. More recently,

[5] Traditionally, it is considered that using the DW has "stigma". In other words, banks are reluctant to borrow at the DW due to the concern that such borrowing may be interpreted as a sign of financial weakness (Armantier *et al.*, 2011). In our model we do not consider stigma explicitly because banks do not have any prior belief about the DW. If banks would only have access to the DW, they would still use it but they would not be able to separate themselves. It is the existence of two facilities with distinct features what allows for separation and a decrease of asymmetric information.

[6] Signaling does not necessarily have to be welfare increasing. In times of a financial crisis, however, increased information on banks' types can prevent market failure. Bouvard *et al.* (2015) and Goldstein and Leitner (2015) document how increased regulatory disclosure can be beneficial in adverse economic states. While we abstract from the optimality of the disclosure decision we analyze one specific mechanism created by the regulator to allow signaling by banks to the market.

other papers have analyzed some unintended consequences of access to LOLR, such as moral hazard leading to excess illiquid leverage (Acharya and Tuckman, 2013) or the risks of unconditional access to LOLR facilities that can create the 'zombie banks' phenomenon (Acharya and Backus, 2009). In this paper, we contribute to the debate on how to design LOLR facilities. We argue that a 'one size fits all'-approach with respect to LOLR policy will force banks into a pooling equilibrium, while the simultaneous offering of several liquidity facilities with differential characteristics allows banks to signal their type (i.e., illiquid versus insolvent) which helps ensure the efficient dissemination of liquidity provisions.

Our paper is also related to the theoretical research on effects associated with DW borrowing. In a recent paper, Ennis and Weinberg (2013) propose a model where informational asymmetries and asset-quality heterogeneity play a crucial role in determining equilibrium interest rates and study the conditions under which DW borrowing may be regarded as a bad signal about the quality of the borrowers. They have two key assumptions: DW borrowing must be at least partially observable, and accessing the DW sends a worse signal than borrowing on the market at a rate higher than the DW rate. Klee (2011) develops a model to explain why Fed funds rates went up as the spread between the DW rate and the target rate went down. In her model banks face exogenous non-pecuniary costs (stigma) on top of monetary costs to access the DW. Contrary to these two papers, in our model the two liquidity facilities do not create any exogenous costs to participants per se. Actually, the DW has better lending terms than the TAF, but it is precisely this greater flexibility of DW the key feature that allow banks to separate themselves and signal their relative strength to funding markets.

On the empirical front, evidence has accumulated on the presence of the DW stigma effects (Peristiani, 1998; Furfine, 2001, 2005; Armantier *et al.*, 2011)[7], and on how LOLR facilities alleviate banks' funding strains and enhance market liquidity (Fleming, 2011). However, ex-ante incentives of banks participating in emergency liquidity facilities have not been extensively studied. In a recent

[7] Armantier *et al.* (2011) use negative abnormal returns or large overnight funding rates in the interbank market to estimate the stigma costs. They do not find strong evidence of such costs. We think that their approach may underestimate those costs for many reasons. First, it likely takes time for markets to identify which banks went to the TAF and which ones to the discount window, in which case, funding costs between the two types of banks would differ after more than a few days of accessing the DW. Second, the authors focus on the highest volatility period during the crisis, in which period even the healthiest corporations were facing extreme increase in funding costs. Third, as detailed above, Klee (2011) documents an increase in the Fed funds rate for banks not accessing the DW, as the spread between the discount rate and the target rate was decreased

paper, Berger *et al.* (2014) analyze the banks that participated in the DW and TAF facilities and their aggregate lending behavior during the recent financial crisis. They find that bank size matters: Small banks receiving funds from DW and TAF were weak banks whereas large banks generally were not. Also, Puddu and Wälchli (2012) find that banks that borrowed TAF funds exhibit ex-ante higher levels of maturity mismatch and have more illiquid collateral.[8] In this paper, we shed new light on the incentive to participate in different LOLR facilities. In particular, we study how banks' access to DW and TAF facilities during the crisis affected market perceptions ex-post.

The rest of the paper is organized as follows: Section 2 explains the institutional features of recent central bank liquidity facilities; we develop the theoretical model in Section 3 and present the interesting stylized facts and main empirical results in Section 4. Section 5 extends our empirical analysis and Section 6 concludes.

2 Central Bank Liquidity Facilities

During the recent financial crisis, the Fed undertook a series of unusual policy actions in order to alleviate the strain on bank funding markets.[9] In addition to easing the term of the DW, the Fed created a number of unconventional programs including a new facility for auctioning short-term credit, the TAF. These were the two main facilities used by depository institutions (DIs).[10] In this section, we provide a brief perspective of the key features of the DW and TAF.

2.1 Discount window lending

The Federal Reserve Act requires discount window credit to be made on a nondiscriminatory basis to all institutions that are eligible to borrow. In August 2007, as a response to the incipient financial crisis, the Fed narrowed the spread in the DW rate over the FOMC's target Fed funds

[8] See also other papers, such as Wu (2008), Gilbert *et al.* (2012) and Drechsler *et al.* (2013) for the European case.

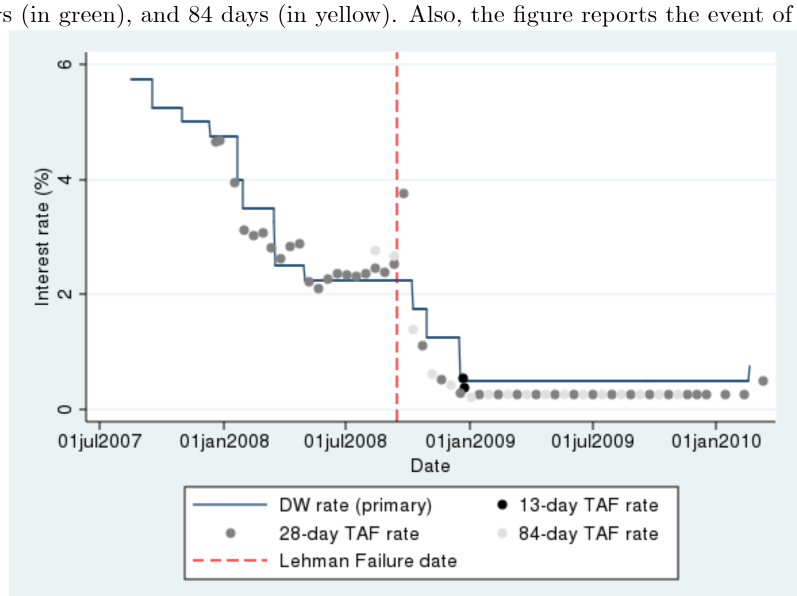
[9] See for example Afonso *et al.* (2011) who document the stressed interbank lending market during the crisis.

[10] There were other facilities, such as the Term Securities Lending Facility (TSLF), the Primary Dealer Credit Facility (PDCF), the Commercial Paper Funding Facility (CPFF) and Term Asset-Backed Securities Loan Facility (TALF), but they were either designed for non-depositary institutions, or their dimension was significantly smaller than the DW or TAF.

rate and increased the allowable term for primary[11] credit borrowing to 30 days from overnight. A few months later (on March 16, 2008), in the wake of the takeover of Bear Stearns by JP Morgan Chase, the Fed further narrowed the spread to 25 basis points and extended the maximum maturity of term primary credit loans to 90 days (see Figure 1). Nevertheless, as shown in Figure 2a, total borrowing from the DW remained low with primary credit loans peaking in late 2008 at just over \$100 billion, and secondary loans at only about \$1 billion in late 2009 (see Figure 2b). See Appendix for further details about the DW before the recent financial crisis.

Figure 1: Borrowing cost of DW and TAF

This figure displays weekly DW primary rates (in blue) and stopout rates for TAF auctions with maturities of 13 days (in red), 28 days (in green), and 84 days (in yellow). Also, the figure reports the event of Lehman failure.



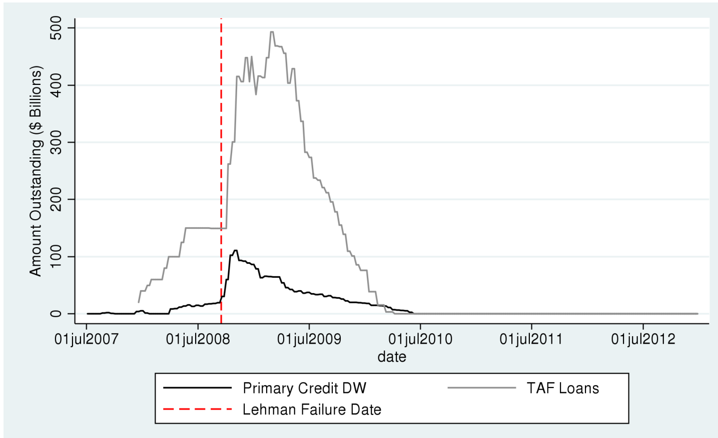
2.2 The Term Auction Facility (TAF)

In response to concerns about the reluctance of banks to use the DW, the Fed introduced the TAF on December 12, 2007. The TAF was a series of biweekly auctions for preset amounts of funding available to DIs eligible for primary credit at the DW, including U.S. branches and agencies of foreign banks.

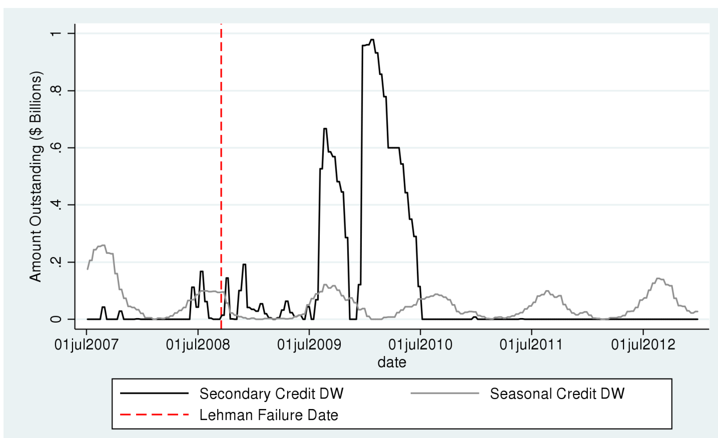
[11] The discount window offers three types of lending programs. The "Primary Credit" program is the principal safety valve for ensuring adequate liquidity in the banking system for sound depository institutions (DIs). Primary credit is priced at a rate above the FOMC's target for the fed funds rate and is normally granted on a "no-questions-asked" basis. There are no restrictions on borrowers' use of primary credit. Priced slightly higher, the "Secondary Credit" is available to DIs not eligible for primary credit. Finally, under the "Seasonal credit", a DI may qualify for funding to meet seasonal borrowing needs due to fluctuations related with construction, college, farming and other sectors.

Figure 2: Total borrowing TAF, and to primary, secondary and seasonal DW.

The figure plots weekly outstanding Federal Reserve credit for the primary DW (panel (a) in blue) and TAF programs (panel (a) in red), and for the secondary DW (panel (b) in blue) and seasonal DW programs (panel (b) in red). The figure is generated using data on DW loans to depositary institutions that were released by the Fed in March 2011 in response to a Freedom of Information Act request and subsequent court ruling. The data include loans to individual institutions made between August 20, 2007 and March 1, 2010.



(a) Primary credit in DW and TAF loans



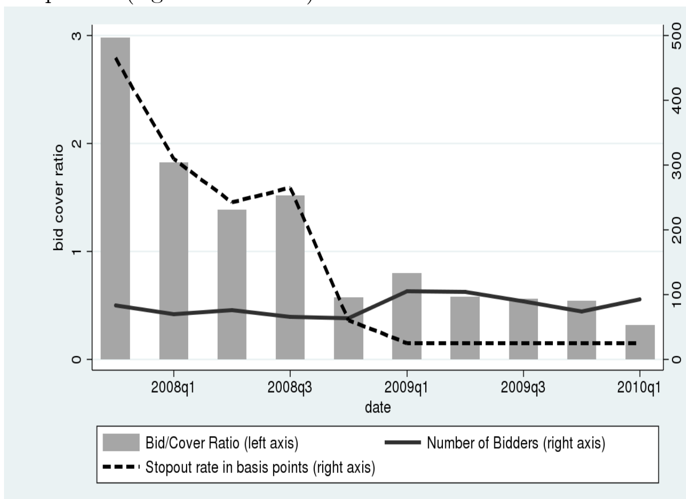
(b) Secondary and seasonal loans in DW

The TAF is a single-price auction, whereby all successful bidders pay the stop-out rate, the interest rate of the last accepted bid which all awarded institutions pay upon maturity. TAF loans, which were offered with a maturity of 28 days, and beginning in August 2008, 84 days, were fully collateralized. Collateral eligibility and valuation procedures were the same as for the DW.

Clearly, the lending terms of the TAF were in all dimensions worse than the DW. Whereas an unlimited amount of money is available on demand through the DW, under the TAF banks needed to wait for three days to access the funds, funds were auctioned on a biweekly basis, there was a

Figure 3: Outcome of TAF auctions

Average bid-to-cover ratio (columns) is computed as the ratio of total submitted bids to total offered TAF funds. Stopout rate in excess of the minimum bid rate (dashed line) is the difference between the stopout rate and the minimum accepted bid rate as set by the Fed. Number of bidders (solid line) is the average number of bidders in auctions held during a given quarter (right hand scale).



cap on individual bids, loans could not be prepaid, loan maturity was limited, and the collateral requirements were the same as under the DW. Absent any stigma effect, banks should be willing to pay more for funds under the DW than under the TAF. Yet during a substantial period of time, banks were willing to pay a premium over the DW rate to access TAF funds (see Figure 1). As the financial crisis ebbed, DW lending rates started to exceed TAF rates in line with what we would expect given the funding terms.

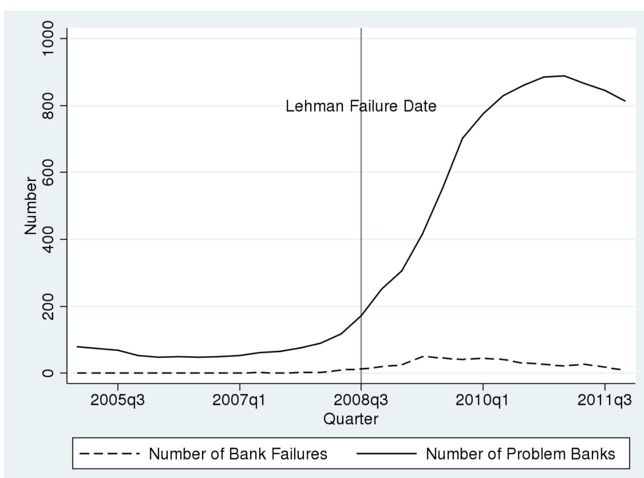
From its creation, borrowing at the TAF was in high demand. As shown in Figure 3 auctions were highly competitive prior to the bankruptcy of Lehman Brothers. Total bids were more than 50 percent larger than total offered funds on average over the pre-Lehman period. Demand for TAF funds continued to rise after the collapse of Lehman exceeding $800 billion in 2009Q1; however, competition among bidders decreased since the Fed doubled the amounts supplied. In response to continued improvements in financial market conditions, the Fed reduced both the amount and maturity of new TAF auctions, until March 8, 2010 when the final auction was held.

2.3 Eligibility for DW and TAF

TAF was a liquidity facility with virtually the same eligibility and collateral criteria as the primary DW. Therefore, both liquidity facilities could be accessed by the same DIs that were in sound financial condition, including branches and agencies of foreign banks. These branches must meet the same soundness criteria as U.S. commercial banks.[12]

Although available data on DW usage do not reveal whether borrowing banks are primary or not, we have some evidence that prior to the failure of Lehman, most institutions that borrowed from the DW were considered as primary by the Fed. The amount of borrowing from the secondary window in the DW was significantly lower than from the primary window (about 100 times less borrowing, see Figures 2a and 2b), and these differences were especially significant in the pre-Lehman period. Also, in that period, the number of problem banks that can be considered as non-primary was very low (see Figure 4). Hence, it is reasonable to assume that most of the banks that borrowed from the DW in the pre-Lehman period were primary and therefore, they had the possibility to borrow from either the DW or the TAF.

Figure 4: Number of bank failures and problem banks in U.S.



Note that it could be argued that the access to TAF could be constrained by some size or scale effects. In particular, the minimum amount that can be borrowed ($10 M) may be too high for some small institutions. However, we document that the smallest bank that borrowed from the TAF in

[12] Foreign banks were active users in the TAF. Benmelech (2012) argue that many of these foreign banks issued liabilities in U.S. money markets that were denominated in dollars. Thus, foreign banks were subject to a roll-over risk and had to rely on special facilities such as the TAF.

the pre-Lehman period had \$146M in total average assets during 2008, and the 5% percentile was \$244 M. This suggests that even relatively small banks were able to win some of the TAF auctions. Therefore, bank size does not seem to have been a constraint and almost all borrowing institutions had the scale to access the TAF if needed.

2.4 Data

Data on DW usage was released following the Freedom of Information Act requests done by Bloomberg News and Fox Business Network on March 31, 2011. It includes the user's name, Federal Reserve District, amount obtained, origination date, and maturity date. The Fed made public the information on banks that borrowed TAF loans on December 1, 2010 as mandated by the Dodd-Frank Act. Data is available from December 12, 2007 to March 8, 2010 (i.e. the life span of the program) and includes the auction date, the borrower's name and location, the interest rate and the type of collateral used, among other variables.

This dataset covers all borrowing institutions including U.S. depository institutions, U.S. chartered, subsidiary banks (FSUBs), and U.S. branches and agencies of foreign banks (FBAs). Because of the unavailability of bank-level data, the latter were dropped from our sample. Interestingly, in the pre-Lehman period, FBAs heavily borrowed from TAF, as did other types of institutions, despite that they were also eligible to borrow from the primary DW facility.[13]

Call Reports provide quarterly financial data for all member banks. We combine this database with the DW and TAF databases using the key attributes (name and Fed region) of all financial institutions that borrowed from the DW and TAF, and manually match these attributes with those available in the Call Reports to identify the certificate number of the bank. We could match with very high certainty above 95% of the names, and discarded institutions that had an ambiguous name.

Following the methodology of Acharya and Mora (2015), we use Call Reports to calculate implicit rates for funding cost by type of instrument, i.e. we divide quarterly interest expenses by

[13] Unlike U.S. depository institutions and other FSUBs, FBAs are integral parts of their mother banks. They are not required to meet specific risk-based capital standards, but in turn, are not permitted to accept domestic retail deposits. Therefore, they are not covered by the Federal Deposit Insurance Corporation (FDIC) and are not required to report bank-level financial information on a stand-alone basis (Goulding and Nolle, 2012).

the quarterly average of the respective instrument and we express it in basis points. As in Acharya and Mora (2015), we eliminate outliers which are less than 0.5% of the sample size.

We use a single macro index ("State Coincident Index") from the Federal Reserve Bank of Philadelphia to summarize the macroeconomic conditions of every state where banks are located. For multi-state banks, we combine branch-level data from the Summary of Deposits (SOD) database from the FDIC to calculate the average exposure of multi-state banks to state macro conditions.

3 Model

Banks have access to a two period investment project that requires an investment normalized to \$1 and pays either R or zero at the end of the second period. Banks can be classified as "good" or "bad". Good banks realize the positive payoff with certainty while bad banks obtain R only with probability $1-\theta$. This type is private information for every bank and denote the ex-ante probability of a bank being good as α. The project is financed through two consecutive periods of short term borrowing. In the second period we assume that markets work frictionless and that banks can borrow from a competitive financial market at the fair market rate given the market's belief about their type. In the first period we assume that banks face a distressed market and are in potential need of a central bank facility to refinance the project. Specifically we assume that the bank does not have access to market funding sources should a refinancing need arise.

We model two possible refinancing needs reflecting the idea that banks can either be illiquid due to the general closure of the market for refinancing, which we refer to as a liquidity shock, or due to the unwillingness of counter-parties to extend financing because of concerns about the bank's asset quality, which we refer to as run. Banks receive a liquidity shock with probability λ independent of their type, in which case they need to refinance their project.[14] We think of liquidity shocks as the inability of a bank to rollover its financing due to adverse market conditions specific to its funding structure. Since banks know their funding structure and can observe market conditions we assume that banks learn whether they will receive a liquidity shock or not. Specifically we assume that a bank knows with certainty at the beginning of the first period whether it will be exposed to

[14] To simplify the exposition of the paper we assume that the bank needs to refinance the whole project.

a liquidity shock or not.

The second possible reason for banks to need refinancing is based on adverse information about the bank's credit quality which does not allow them to roll over very short-term funding, or causes a sudden withdrawal of callable interbank or retail deposits. We refer to the case of information driven refinancing needs as a "run", and to simplify the exposition we assume that only bad banks that did not experience a liquidity shock can be subject to a run with probability ρ, while good banks will never experience a run. Runs occur in the middle of the first period (after the liquidity shock is revealed). Since runs can be based on informational cascades and rumors we assume for simplicity that the bad bank has no advance information about runs.

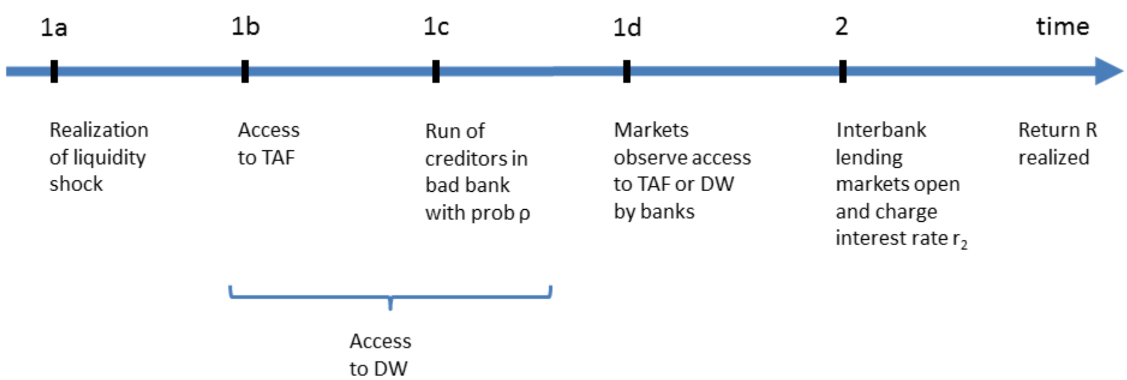
Consistent with the liquidity facilities provided by the Fed to commercial banks during the recent crisis, we assume that the Fed provides two funding facilities that banks can access to refinance their project, the term auction facility (TAF) and the discount window (DW).[15] We capture two stylized facts about these facilities in our model: first, they offer funds at different rates, specifically banks can borrow funds at rates r_T and r_D for the TAF and DW, respectively. Second, the TAF facility is less flexible than the DW. TAF funds cannot be accessed instantly because the Fed requires three business days to transfer funds to successful bidders and because TAF auctions are not held on a daily basis. We capture this institutional feature by assuming that TAF funds are only available at the beginning of the period.

We assume the following timeline (see Figure 5): In period 1a, the bank observes whether it will receive a liquidity shock or not. In period 1b, the Fed offers access to TAF funding. Banks can also access DW in that period. After banks decide to use TAF/DW or not, bank runs are realized (period 1c). A bank experiencing a bank run that has not secured TAF or DW funding in period 1b is forced to refinance through the DW in period 1c. In period 1d the market can observe whether a bank has accessed the TAF, the DW, or did not use the liquidity facility, and updates their belief about the bank's type based on that information. In period 2 markets are open and banks can borrow in the market at a rate that depends on their perceived type. At the end of period 2 the project return is realized, the bank repays its obligations if possible and closes. Note

[15] Note that in this model we assume that all banks are qualified by the Fed to access both facilities. This is consistent with the facts observed previously about the low use of the secondary DW and the low number of troubled banks before the failure of Lehman (see Figures 2a, 2b and 4).

that after period 1a there are four types of banks: good banks with or without a liquidity shock, and bad banks with or without a liquidity shock. In addition, in period 1c the bad bank without a liquidity shock can experience a run (with probability ρ).

Figure 5: Timeline of the model



3.1 Separating equilibrium

We propose that banks use the TAF as a signaling device and hence conjecture a separating equilibrium in which banks that learn that they will be hit by a liquidity shock access the TAF, bad banks that experience a run access the DW, and banks that experience neither a run nor a liquidity shock do not access a liquidity facility. We solve the model by backward induction.

Banks that do not access the liquidity facility are either good banks that did not receive a liquidity shock or bad banks that received neither a liquidity shock nor a run. Denote by ξ_0 the probability that a bank is good given that it has not accessed any facility, which is

$$\xi_0 = \frac{\alpha(1-\lambda)}{\alpha(1-\lambda)+(1-\alpha)(1-\rho)(1-\lambda)} = \frac{\alpha}{\alpha+(1-\alpha)(1-\rho)}. \tag{1}$$

Since both types of banks access the TAF upon receiving a liquidity shock the market cannot learn from observing a bank accessing the TAF and thus sets the probability of being a good bank upon accessing TAF equal to the unconditional probability, $\xi_T = \alpha$. Since we assumed that only bad banks are subject to runs, accessing the DW fully reveals the bank's type and thus $\xi_D = 0$. The market's belief of the bank being of the good type depends on the bank's actions as follows.

Lemma 1. *The markets belief that a bank is of the good type is highest for banks that do not access any liquidity facility and lowest for banks that access the discount window, i.e.* $\xi_D \leq \xi_T \leq \xi_0$.

The finding in Lemma 1 is consistent with the widely cited stigma effect that banks face when accessing the discount window. In the second period the market will set the competitive interest rate to break even given a belief ξ that the bank is good. Good banks always repay and bad banks default with probability θ. The interest rate r_2 for the second period will be set for investors to break even and thus solve the equation

$$1 = (1 - \xi)(1 - \theta)(1 + r_2) + \xi(1 + r_2), \tag{2}$$

or

$$r_2 = \frac{\theta(1 - \xi)}{\theta\xi - \theta + 1}, \tag{3}$$

where – because of the separating equilibrium – ξ is either zero, if the bank has accessed the DW, α in case that the bank has accessed TAF, or ξ_0 if the bank did not access a liquidity facility.

The following lemma shows with detail the effect of the parameters on r_2 and ξ_0 (see Appendix for proofs of all theoretical results):

Lemma 2. *The second period interest rate* r_2 *is increasing in the probability of default of the bad bank* θ*, and decreasing in the market's belief that the bank is good* ξ*. The second period interest rate for banks that do not access a liquidity facility,* $r_2(\xi_0)$*, is decreasing in the fraction of good banks* α*, and the probability of a run,* ρ*. The markets belief of a bank being of the good type given that it has not accessed any Fed funding,* ξ_0*, is increasing in* α *and* ρ*.*

Most comparative statics in Lemma 2 are intuitive. The set of banks that do not access a liquidity facility are comprised of good banks without liquidity shock and bad banks that have neither a liquidity shock nor a run. The quality of this pool increases with the ex-ante number of good banks α and the probability of a run, ρ, as more runs reduce the number of bad banks in the pool. As the pool quality increases the second period interest rate decreases.

From Lemmas 1 and 2 we can rank the second period interest rates as a function of the banks' first period financing needs:

$$r_2(\xi_D = 0) = \frac{\theta}{1-\theta} \geq r_2(\xi_T = \alpha) \geq r_2(\xi_0) \geq r_2(\xi = 1) = 0. \tag{4}$$

Banks that access the DW are assessed worse by the market and pay higher financing rates on the second period. Nevertheless, the DW can be attractive for the bad bank due to its flexibility. If the bad bank has no liquidity shock it can speculate that it will not experience a run and can pool with the good banks that do not need to access funding from the Fed and thus receive a favorable interest rate in the second period as $r_2(\xi_0)$. In the case of a run the bad bank's type get revealed and it has to pay a higher second period rate. If the probability of a run is not too high the opportunity to pool with the good banks in the absence of a run can create enough value for the bad bank to prefer the flexible DW over the more rigid TAF.

The good bank's profit function is then as follows: if it gets a liquidity shock then it will access the TAF at cost r_t, it will be revealed to the market that it is a good bank with probability $\xi_T = \alpha$, and the funding cost for the second period is $r_2(\alpha)$. Therefore, the good bank that receives a liquidity shock obtains a profit of

$$\pi_{g,l} = R - (r_t + r_2(\alpha)). \tag{5}$$

If the good bank is not hit by a liquidity shock then it does not need any funding in the first period but needs access to funding at $r_2(\xi_0)$ in the second period. The profit of the good bank without liquidity shock is then:

$$\pi_{g,n} = R - r_2(\xi_0). \tag{6}$$

The bad bank, which will realize the payoff of R only with probability $(1-\theta)$, can also learn that it will realize a liquidity shock in which case it would access the TAF and face the same funding costs as the good bank.

$$\pi_{b,l} = (1-\theta)(R - (r_t + r_2(\alpha))). \tag{7}$$

Otherwise it can experience a run in which case it has to access the DW at cost r_d and is identified as bad bank resulting in a funding cost of $r_2(0)$ in the second period, or it can have no run, in which case it will pay $r_2(\xi_0)$ in the second period. Its expected profit is then

$$\pi_{b,n} = (1-\theta)(R - \rho(r_d + r_2(0)) - (1-\rho)r_2(\xi_0)). \tag{8}$$

We propose the following separating equilibrium:

Separating Equilibrium. *In the separating equilibrium, the good bank with a liquidity shock, and the bad bank with a liquidity shock go to TAF. Also, the bad bank without a liquidity shock goes to DW if it does experience a run. Finally, the good bank without a liquidity shock and the bad bank without a liquidity shock and without a run do not use any liquidity facility.*

3.2 Characterization of separating equilibrium

For this equilibrium to be stable both types of banks must not have an incentive to deviate from the conjectured strategies. First neither the good nor the bad bank should find it profitable to access the DW rather than the TAF when receiving a liquidity shock. By accessing the DW instead of the TAF banks could profit from lower finding costs if $r_d < r_t$ but suffer from being identified as bad banks by the market and thus paying a higher interest rate in the second period. The corresponding conditions are

$$R - (r_t + r_2(\alpha)) \geq R - (r_d + r_2(0)) \Leftrightarrow \tag{9}$$

$$r_d + r_2(0) - r_2(\alpha) \geq r_t. \tag{10}$$

for the good bank and

$$(1-\theta)(R - (r_t + r_2(\alpha))) \geq (1-\theta)(R - (r_d + r_2(0))), \tag{11}$$

which is identical, for the bad bank, respectively.

Second, if the good bank does not receive a liquidity shock it could still access the TAF and invest the proceeds in a riskless storage technology for which we assume a normalized return of zero. The corresponding incentive compatibility constraint is

$$R - r_2(\xi_0) \geq R - (r_t + r_2(\alpha)) \Leftrightarrow \tag{12}$$

$$r_2(\xi_0) - r_2(\alpha) \leq r_t. \tag{13}$$

Third, the bad bank could access the TAF even if it has no liquidity shock and store the proceeds. The bank could then avoid accessing the DW and being identified as bad bank in case there is a run. The corresponding incentive compatibility constraint is

$$(1-\theta)(R - \rho(r_d + r_2(0)) - (1-\rho)r_2(\xi_0)) \geq (1-\theta)(R - (r_t + r_2(\alpha))) \Leftrightarrow \tag{14}$$

$$\rho r_d + \rho r_2(0) + (1-\rho)r_2(\xi_0) - r_2(\alpha) \leq r_t. \tag{15}$$

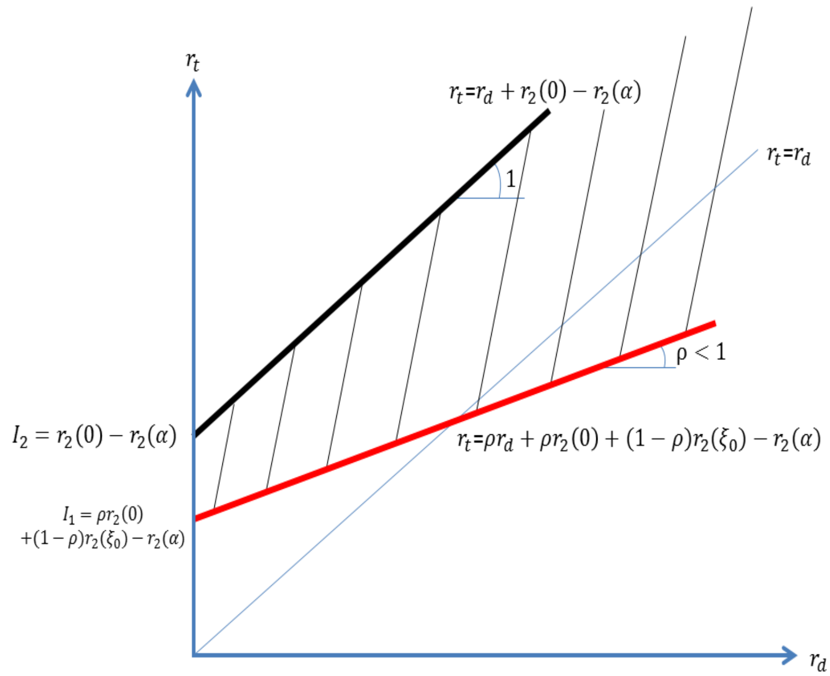
Note that Equations (10) and (11) are identical, so we can discard one of them. Also, because we assume that $r_d \geq 0$ and $r_t \geq 0$, and $r_2(0) \geq r_2(\alpha) \geq r_2(\xi_0)$ Equation (13) can be discarded. Therefore, a separating equilibrium is defined by (10) and (15), which leads to

Proposition 1. *The separating equilibrium is fully characterized by equations (10) and (15).*

The interest rates for the liquidity facilities, r_d and r_t that support the separating equilibrium are illustrated in the striped region in Figure 6. Because $\rho \leq 1$ and $r_2(0) \geq r_2(\xi_0)$ from Equation (4) it is easy to show that the line corresponding to constraint (10) is above the one of constraint (15) opening up the equilibrium region between them.

We can see that the equilibrium TAF rate exceeds the DW rate as long as the latter is not too high, which is consistent with the rate pattern observed in the recent financial crisis. Banks are willing to pay a premium to access the TAF over the discount window because of the associated signaling benefits. It is also straightforward to show that the equilibrium region is shrinking in the probability of an information driven run ρ such that it collapses to a single line when $\rho = 1$.

Figure 6: Separating equilibrium with flexible discount window



As the bad banks are more likely to be caught in the market through a run the opportunity of pooling with the good banks that have no liquidity shock and enjoying a low second period rate vanishes, which makes the DW less attractive. The rate differential between r_t and r_d then merely mirrors the rate differential of TAF and DW banks for the second period. Also, in this case, the two incentive constraints (10) and (15) are satisfied with equality.

We characterize some of the properties of the equilibrium in the following proposition :

Proposition 2. *Properties of separating equilibrium:*

- *If r_d is small enough, then $r_t > r_d$.*
- *If $\rho \to 1$, then $r_t = r_d + r_2(0) - r_2(\alpha)$ and $r_t > r_d$ for any $r_d \geq 0$. Also, the equilibrium region of r_t is shifted up (i.e, r_t increases) as $\rho \to 1$.*
- *If θ increases, the equilibrium region of r_t does not have a clear behavior (I_2 increases, but I_1 does not have a clear pattern). However, if $\theta \to 1$ then $r_d \to +\infty$.*

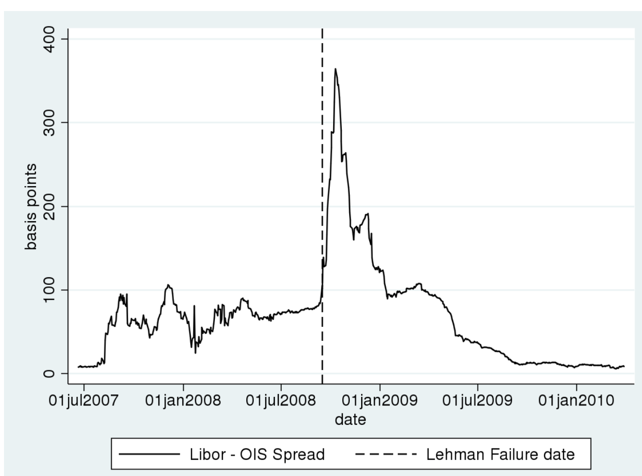
- *If α increases, the equilibrium region of r_d is shifted down (i.e, r_t decreases)*

4 Main empirical results

4.1 First period predictions from the model

The theoretical model considers two periods with the first one being of heightened uncertainty and high financial stress. To provide empirical evidence of the model's predictions, we consider 2007 as the first period. The second period is assumed to be the year 2010 in which turbulence had scaled down significantly and markets reacted to the observed access of banks to the different facilities in the first period. This temporal division can be seen in Figure 7, which shows the LIBOR-OIS spread in the period 2007-2010. The figure illustrates first a progressive increase and then an abrupt increase of the LIBOR-OIS spread around the failure of Lehman, and subsequently a progressive decrease of the spread in 2009 and 2010. This spread has been widely used as an indicator of financial stress in the interbank-lending markets during the recent crisis (Taylor and Williams, 2009; Sengupta and Tam, 2008).

Figure 7: LIBOR-OIS Spread



The model predicts that banks either access the DW or the TAF, but not both. Table A.1 in Appendix reports descriptive statistics on banks' usage of the DW and TAF facilities before and after the collapse of Lehman. Banks that raised more than 95% of their Fed funds from DW (as percentage of total funds from TAF+DW) are called “DW banks”. Similarly, “TAF banks” obtained more than 95% of their Fed funds from TAF (as percentage of total funds from TAF+DW). Banks that do not enter in either category, are classified as "other". These are banks that either did not have a clear access pattern to these facilities, or did not use them at all. The great majority of U.S. banks are classified as "other".

4.1.1 Characteristics of banks accessing liquidity facilities

The model predicts that in a separating equilibrium banks access liquidity facilities depending on their level of liquidity and solvency in the pre-Lehman period. Table C.1 in Appendix shows statistics for key balance sheet variables in 2007 for banks that mainly used DW, TAF and the rest of the banks in this period. Variable definitions are provided in the appendix. In the right side of the table we report p-values for one-side tests of significance and we show the three null hypotheses that we consider. These hypotheses compare means of key balance sheet variables for every type of bank. The p-values show that we cannot reject the null hypotheses that DW or TAF banks are more liquid than the rest of the banks. On average, the rest of the banks have a much larger level of liquidity than DW or TAF banks. This is consistent with the idea in our model that if a bank does not have a liquidity shock, it will not use the DW or TAF.

Also, the model predicts which banks access liquidity facilities depending on the level of solvency. Our separating equilibrium implies that if a bank uses the DW, it is necessarily a bad bank. On the contrary, the usage of TAF or the lack of usage of any liquidity facility does not have a clear implication in terms of the low solvency of the bank. Related with this prediction, we reject at very low significance levels (2% or less) that the DW banks have more Tier 1 capital ratios than TAF banks or the rest of the banks. We also find that DW banks tend to have assets of lower quality than TAF banks (although higher quality than the rest of the banks), and that their volatility of their return over assets (ROA) is also higher than TAF banks. A similar result is found when we compare z-scores (distance to default) or when we consider levels of ROA or return on equity (ROE). These results suggest that banks that accessed the DW were less solvent than TAF banks and the rest of the banks. Results may not be conclusive, however, because there are other variables that do not show a similar behavior (such as the loan charge-offs or foreclosures). Also, it could be argued that some variables that affect solvency may be unobserved. Perhaps a more definitive argument is obtained when we observe the number of defaults among banks that accessed the DW. Table 1 shows an interesting simple descriptive statistic. A great majority of banks that failed after the failure of Lehman accessed the DW before the failure of Lehman. Following Figure 4, most of these defaults happen after late 2009. Only 3 banks that accessed TAF failed in the post-Lehman period, whereas 50 banks that accessed the DW failed in the post-Lehman period. This is also true when we consider the percent of failed banks among the banks that accessed every facility (12.9% for DW banks, 6,67% for TAF banks).[16]

Table 1: Banks that accessed DW and TAF before Lehman and failed after Lehman

This table shows statistics about failures after the failure of Lehman Brothers and access to TAF and DW before the failure of Lehman Brothers. DW main= Dummy equal to 1 if bank was DW mainly in before Lehman period. TAF main= Dummy equal to 1 if bank was TAF mainly in before Lehman period.

	Total access	Total fail	% fail
DW main	387	50	12.9%
TAF main	45	3	6.67%

4.1.2 TAF and DW rates

Another prediction of the model for the signaling period is a relationship between TAF and DW rates where the latter are low (see Proposition 2). In Figure 1, we compare TAF stop-out rates and DW rates. TAF rates are consistently higher than DW rates in the months before the failure of Lehman (with a peak difference of 150 basis points in the auction of September 22th, 2008). Moreover, the term of TAF loans does not seem to play an important role in determining rates since we do not observe a differential effect across the 28-day and 84-day terms. It cannot be that banks overbid in the TAF auction just to secure an allocation of funds. Banks had an outside option with unlimited supply of funds (DW), so if a bank was in need of cash it could still go to the DW after being unsuccessful in the TAF auction and secure funds at a lower rate. Banks had to have an important reason to overpay in the TAF auction, which we believe is signaling. After the failure of Lehman, the relationship between DW and TAF rates is just reversed, with rates being

[16] FBAs heavily borrowed from TAF, as did other types of institutions, despite that they were also eligible to borrow from the primary DW facility. These FBAs were typically very large multinational banks that were in general considered to be solvent and none of them failed. Therefore, their behavior is also consistent with the predictions of our model.

approximately flat for about one year (TAF rates was stabilized at 25 bps and the DW rate was equal to 50 bps).

These empirical facts have been already studied with much more detail than in our paper for the year 2008 by Armantier *et al.* (2011). These authors have access to the confidential bids submitted by the TAF participants, and not only the stop-out rate. The bids submitted by participants were accepted in descending order of rates until the amount of funds supplies by the Fed was exhausted (which determines the stop-out rate). Note that our simple theory model abstracts from any complex auction bidding behavior and just considers a unique equilibrium rate, r_t, that is generated in the TAF auction (the stop-out rate) and is consistent with the separating equilibrium. Since the bids submitted by TAF participants represent the willingness to pay of participants for the TAF funds, and therefore represent the willingness to separate from the DW, not observing the TAF bids raises concerns about how the bidding behavior of TAF participants is described by our model. However, we believe that the empirical facts support our model. First, TAF participants that won the TAF auctions had to bid necessarily more than the stop-out rate. Second, Armentier *et al.* (2011) show that the fraction of bids that were above the DW rate was increasing as the auction date was getting close to the failure of Lehman. In addition, in the two months before the failure of Lehman, more than 80% of the bids were above the DW rate, and in the first auction after the failure of Lehman (when TAF premium with respect to the DW was the highest), this percentage was close to 100%. Therefore, most banks that bid in the TAF auction and did not win, bid above the DW rate. Hence, most bids submitted by banks that participated in the TAF were well above the DW rate.

Another possible concern is the role played by the FBAs in determining TAF rates since they accounted for about 60% of the borrowing in the TAF in the pre-Lehman period. But as was outlined above, because they were also eligible to the DW, we believe that FBAs did take into account the stigma effect of DW as any other institution. Also, the stop-out rate in the TAF auctions could be the result of the bids by the FBAs, and not by the rest of the U.S. banks. However, the U.S. banks that won the auction necessarily had to bid above the stop-out rate, and as discussed before, most banks submitted a bid above the DW rate.

4.2 Second period predictions

We show next some empirical results that confirm the model's key predictions for the second period. In a first set of results, we provide evidence that banks' future funding costs are correlated with their decisions to borrow from the DW or TAF in the first period. The model assumes that the funding cost of a bank in the second period reflects markets' perception of its riskiness based on its actions in the first period (the "signaling effect"), and is not simply determined by the rate paid to access the liquidity facilities from the Fed which are just other sources of funding for banks. These perceptions are based on the assumption that markets are able to identify banks that have access to these facilities, even if this is usually confidential information. In our paper, as in other papers that have studied stigma effects, we assume that in practice markets are able to identify these banks due to the interconnectedness of nature of the financial markets and the existence of informal information flows such as rumors regarding the identity of these banks.[17]

To identify this effect, we build a panel with quarterly bank-level information for years 2007 and 2010. Since the amount borrowed from TAF and DW could affect the overall funding cost of banks if it represents a large share their liabilities, we use the year 2010 where the access to DW and TAF was significantly reduced compared with previous years (Figure 2a). In practice, this is not problematic because the share of DW and TAF loans in banks' total liabilities was very small for all years, and for 2010 in particular.

4.2.1 Baseline evidence

For our analysis we use econometric analysis of banks' funding costs and their funding sources where we can control for their key variables, including bank-specific variables and macroeconomic indicators. All variables are defined in Appendix C.1.

[17] Courtois and Ennis (2010) argue that, because of the interconnected bilateral nature of the interbank lending market, it would not be hard for other banks to infer the identity of institutions that borrow from the DW. Furfine (2005) finds evidence on DW stigma using data from before the recent crisis, while Armantier *et al.* (2008) find evidence of stigma effects using federal funds market data during the first year of the recent financial crisis.

We consider the following econometric model

$$\text{FundingCost}_{i,t} = \alpha_{TAF} TAF_{i,pre} \times Post_t + \alpha_{DW} DW_{i,pre} \times Post_t + \alpha_X X_{i,t} + c_t + \mu_i + \varepsilon_{i,t}, \quad (16)$$

where $\text{FundingCost}_{i,t}$ is the cost of funding (implicit rate) reported by bank i in quarter t, $X_{i,t}$ are bank-specific variables, c_t are quarterly fixed-effects, and μ_i are bank-fixed effects. We use the year 2010 as the post-Lehman period, and the year 2007 as the pre-Lehman period. $TAF_{i,pre}$ ($DW_{i,pre}$) is a dummy variable that takes the value of one if bank i accessed the TAF (DW) in 2008. $Post_t$ is a dummy variable equal to one for the quarters corresponding to the post-Lehman period. To study the cost of funding, we use total interest expense as a fraction of total liabilities. We also show disaggregated results using cost of funding for domestic deposits, transaction accounts, saving accounts, insured and uninsured time deposits, foreign deposits, interbank borrowing, subordinated debt and other types of borrowing. The coefficients corresponding to the interaction terms $TAF_{i,pre} \times Post_t$ and $DW_{i,pre} \times Post_t$ are our main variables of interest.

This fixed effects specification is rich enough to control for any possible omitted variable bias that could arise from the correlation between unobserved time-invariant bank fixed effects and our two main variables of interest. In the next sections, we extend the model to verify the robustness of our empirical results.

In the econometric model (16), a natural hypothesis to test from our theoretical model is

$$\text{Hypothesis 1 } (H_1, \text{ Funding Cost}) : \alpha_{DW} \leq \alpha_{TAF}. \quad (17)$$

If we reject Hypothesis 1, then we find empirical evidence that banks that access the DW in the pre-Lehman period have a higher funding cost than banks that access the TAF. This is consistent with our theoretical model (see Lemma 1). We can test Hypothesis 1 considering the total funding costs, or different types of funding used by every bank.

Table 2: Regressions for funding cost for years 2010 and 2007 (total and by type of funding source).

This table shows results of fixed effects regressions of funding cost by type of funding source. We show results total interest expense (as a % of total liabilities) in (1); interest expense for domestic deposits (as % of domestic deposits) in (2); interest expense for transaction accounts (as % of transaction accounts) in (3); interest expense for saving accounts (as % of saving accounts) in (4); interest expense for time deposits of less than 100,000 USD (as %) in (5); interest expense for time deposits of more than 100,000 USD (as %) in (6); interest expense for foreign deposits (as %) in (7); interest expense for interbank borrowing (as % of interbank borrowing) in (8); interest expense for subordinated debt (as % of subordinated debt) in (9); and interest expense for other borrowing (as % of other borrowing) in (10). All regressions use quarterly data for banks in 2010 (post-Lehman period) and 2007 (pre-Lehman period). DW= Dummy equal to 1 if bank was DW mainly in the pre-Lehman period. TAF= Dummy equal to 1 if bank was TAF mainly in the pre-Lehman period. Post= Dummy equal to one for the post-Lehman period (2010), and equal to zero for 2007. TARP= Dummy equal to 1 if bank was part of the TARP program.

	Total	Domestic deposits					Foreign	Interbank	Subordin.	Other
	funding	All	Transaction	Saving	Time depos.	Time depos.	deposits	borrowing	debt	borrowing
	cost	deposits	accounts	accounts	(<100)	(>100)				
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$DW_{pre} \times Post$	-0.0337***	-0.0270***	-0.0169	-0.0339**	0.0139	-0.0864***	-0.162**	-0.0294	-0.0175	-0.0464*
	(0.00784)	(0.00783)	(0.0141)	(0.0137)	(0.0153)	(0.0222)	(0.0806)	(0.0358)	(0.161)	(0.0274)
$TAF_{pre} \times Post$	-0.0999***	-0.0769**	0.0218	-0.0386	-0.0279	-0.102	-0.287**	-0.246**	-0.00662	-0.177
	(0.0219)	(0.0336)	(0.0462)	(0.0463)	(0.0472)	(0.0754)	(0.140)	(0.0959)	(0.229)	(0.115)
TARP	-0.0493***	-0.0544***	-0.0166*	-0.0749***	-0.0131	-0.0657***	0.225***	0.00460	-0.172	-0.0164
	(0.00507)	(0.00542)	(0.00922)	(0.00916)	(0.00973)	(0.0120)	(0.0839)	(0.0309)	(0.117)	(0.0206)
Asset (log)	0.0248***	0.0184*	0.0220***	-0.0433***	0.0596***	0.0382***	-0.207*	0.0155	0.0621	-0.0398
	(0.00829)	(0.0103)	(0.00747)	(0.0114)	(0.0106)	(0.0138)	(0.121)	(0.0326)	(0.116)	(0.0258)
ROA	-0.00824***	-0.00470**	-0.000779	-0.00397	0.00193	0.00165	-0.0226	0.0126	-0.00159	-0.00208
	(0.00241)	(0.00195)	(0.00128)	(0.00243)	(0.00293)	(0.00324)	(0.0532)	(0.0111)	(0.0172)	(0.00547)
Liquidity ratio	3.99e-07	1.89e-07	-6.66e-06***	0.000225*	-9.23e-05***	-3.24e-08	6.58e-05	1.03e-07	-2.24e-05	5.35e-07
	(3.64e-07)	(2.62e-07)	(8.76e-07)	(0.000131)	(1.08e-05)	(1.69e-07)	(8.39e-05)	(1.41e-06)	(1.65e-05)	(5.22e-07)
Sens. to market risk	-0.000416***	-0.000260*	1.92e-07	0.00246***	2.74e-05	-0.000158	-0.00648***	0.00322***	-0.000247	-0.000203
	(0.000122)	(0.000157)	(0.000122)	(0.000173)	(0.000174)	(0.000224)	(0.00190)	(0.000670)	(0.00258)	(0.000522)
Chargeoffs	-0.00666***	-0.00402**	0.000447	-0.0140***	0.00245	0.00164	-0.0274	0.00274	-0.0217	-0.00260
	(0.00166)	(0.00197)	(0.00108)	(0.00208)	(0.00218)	(0.00325)	(0.0310)	(0.00746)	(0.0207)	(0.00516)
Funding mix	-7.76e-05***	-8.55e-05***	1.58e-05	-0.000884	-0.000125	-0.000133	0.0355	0.000166***	7.78e-05**	0.000397***
	(1.87e-05)	(2.16e-05)	(2.53e-05)	(0.00103)	(0.000104)	(0.000229)	(0.0407)	(1.53e-05)	(3.15e-05)	(8.27e-05)
High risk securities	0.000437	-0.000502	-0.00230	-0.00262*	0.000279	0.00258	0.0198*	-0.00897*	0.0381**	-0.00109
	(0.00126)	(0.000771)	(0.00151)	(0.00154)	(0.00113)	(0.00202)	(0.0107)	(0.00480)	(0.0186)	(0.00360)
Long term securities	0.00150***	0.00164***	0.000589***	0.00274***	0.000435	0.000563	-0.0123**	-0.000149	-0.00922	-0.00452***
	(0.000224)	(0.000206)	(0.000206)	(0.000315)	(0.000276)	(0.000348)	(0.00528)	(0.00133)	(0.00928)	(0.00107)
std. deviation ROA	-0.00973***	-0.00646***	-0.000268	0.000231	-0.00692**	-0.00260	-0.0167	0.00129	-0.00256	-0.00332
	(0.00235)	(0.00231)	(0.00183)	(0.00262)	(0.00299)	(0.00404)	(0.0216)	(0.0143)	(0.0185)	(0.00832)
Z-score	-4.69e-06***	-4.58e-06***	8.62e-07	-7.89e-06***	-5.86e-06*	-8.24e-06***	-0.000190***	2.39e-06	-0.000127	-3.04e-05***
	(1.35e-06)	(1.27e-06)	(1.87e-06)	(2.88e-06)	(3.18e-06)	(3.07e-06)	(5.62e-05)	(1.15e-05)	(8.62e-05)	(8.53e-06)
Bank age	-0.158***	-0.156***	-0.0353***	-0.114***	-0.214***	-0.228***	-0.277***	-0.263***	-0.112***	-0.0928***
	(0.000961)	(0.000958)	(0.00112)	(0.00155)	(0.00141)	(0.00163)	(0.0279)	(0.00636)	(0.0319)	(0.00401)
Other bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarterly fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	64,490	64,483	57,903	57,955	57,936	57,898	672	21,945	1,906	41,862
Number of banks	8,763	8,762	7,912	7,899	7,902	7,917	103	4,718	362	6,698
R squared	0.890	0.890	0.172	0.703	0.828	0.776	0.769	0.380	0.245	0.118

H_1 : Funding cost for DW banks in post Lehman period ($DW_{pre} \times Post$) $\leq$ Funding cost for TAF banks in post Lehman period ($TAF_{pre} \times Post$)

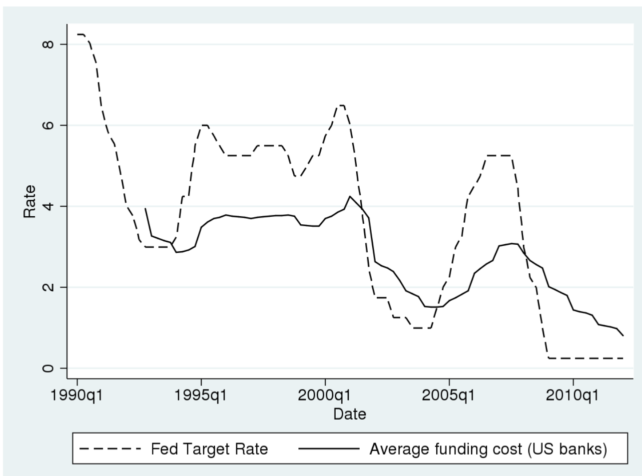
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
15% significance	REJECT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	REJECT
10% significance	REJECT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT
5% significance	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The estimated parameters of the fixed effects regression for funding cost of model (16) are presented in Table 2. We have omitted some bank controls for space considerations. All banks experienced a significant drop in their 2010 overall funding costs relative to 2007, reflecting the environment of low nominal interest rates that prevailed during this period (see Figure 8). However, consistent with the prediction of the model, total funding cost of TAF banks decreased more than DW banks (about 10 bps for TAF banks and 3 bps for DW banks). We also look with detail to the different sources of funding. We find a significant and economically large effect on interbank borrowing. TAF banks paid lower funding cost for interbank borrowing compared to DW banks (a difference of $24 - 3 = 21$ basis points).

Figure 8: Fed target rate vs. Average funding cost for U.S. Banks



In general, we do not find large or significant effects for the rest of the sources of funding. When considering individual deposits, we do not find significant differences. Interestingly, on aggregate we find a small difference of $7.69 - 2.7 \approx 5$ bps when considering all deposits. We expect to observe a small effect for domestic deposits since the deposit insurance limit was increased to 250k per beneficiary in the middle of our sample.[18] Regarding other types of borrowing, we also find some relatively large difference (but significant only at the 15% level).

Compared to DW banks, this lower funding cost for TAF banks translates in annual savings of \$82.9 million when considering interbank borrowing, and \$1,323 million when considering funding

[18] From Oct 14, 2008 until December 2012 the FDIC increased the Deposit insurance from 100k to 250k. Unfortunately, the Call Reports do not show deposits of less than 250,000 for years before 2009. Therefore, we cannot use the new deposit insurance limit in our difference-in-difference regressions that use years 2007 and 2010.

costs for total liabilities. Interestingly, these savings are much larger than the additional funding cost (compared to DW banks) of $172.6 million paid by TAF banks on the auction of September 22nd, 2008. This result suggests that TAF banks were obtaining overall a profit from using the TAF despite the initial larger cost paid at the height of the crisis, as shown by our model.

4.2.2 Intensity of access to DW and TAF

The previous results assume that the effect on funding cost for banks that use the DW or TAF is independent of the total amount borrowed. This is a simplistic view of the behavior of banks. We would expect that the more aggressive the banks are using these two liquidity facilities, the larger the effect on the funding cost. Since signaling is costly for TAF banks because they have to pay more than DW banks, funding markets should take this into account and react differently to banks that are more aggressive using these facilities.

Actually, there is some anecdotal evidence that some banks used the TAF marginally without having a real need for that. For instance, in August 2007, Citigroup, Bank of America, JPMorgan-Chase and Wachovia borrowed each $500 million from the DW, which is an insignificant amount compared to their size. In a joint statement, JPMorgan, Bank of America and Wachovia alleged that they were using the discount window in an effort to *"encourage its use by other financial institutions."*[19] According to Jerry Dubrowski, a spokesman for Bank of America *"we participated at the request of the Federal Reserve to help stabilize the global banking system in a period of unprecedented stress [...] At the time we were participating, we weren't experiencing liquidity issues."*[20] This anecdotal evidence shows that some banks may have used some Fed liquidity facilities for reasons that did not have anything to do with their financial situation. Hence, we would expect that banks that had real needs of using these two facilities would be much more aggressive using them because they have a real need to use them.

To verify this effect, we modify model (16) by considering the intensity of access to the TAF or

[19] *"Big U.S. banks use discount window at Fed's behest"*, The New York Times, August 23, 2007.
[20] *"Bank of America Kept Tapping Fed Facility After 2007 Show of 'Leadership'"*, Bloomberg, March 31, 2011

the DW. We estimate the following equation:

$$\text{FundingCost}_{i,t} = \alpha_{TAF} AmtTAF_{i,pre} \times Post_t + \alpha_{DW} AmtDW_{i,pre} \times Post_t + \alpha_X X_{i,t} + c_t + \mu_i + \varepsilon_{i,t}, \quad (18)$$

where $AmtTAF_{i,pre}$ and $AmtDW_{i,pre}$ are defined as the log of the ratio of total amounts borrowed in the TAF and DW as a fraction of total assets.

The results we find are consistent with our prior conjecture and are shown in Table 3. Banks that increase their borrowing from TAF by 1% as a fraction of their total assets experience a decrease in the post-Lehman funding cost in the interbank borrowing markets of 10 basis points. The effect for the DW is about 3.5 bps, therefore the difference between both types of banks is about 6.5 bps. When considering other types of funding, we do not find an effect in domestic deposits. We find an effect in foreign deposits and other type of borrowing. We considering total funding cost, the difference is economically small, and equal to about 3 bps.

4.2.3 Interacting with bank riskiness pre-Lehman

The equilibrium in our model makes several interesting predictions. First, since the only banks that use the DW are bad banks, we should expect that banks that are relatively in bad condition tend to use more DW than TAF. Second, since banks that use the DW are banks that experience a run, but do not experience a liquidity shock, we should expect that DW banks are more liquid than TAF banks. We test these predictions by extending the model in (16) to study the specific effect on banks that were considered to take too high risks or were too liquid in the pre-Lehman period. In particular, we augment (16) by including interaction terms $HighRisk_i$ and $LowL_i$. $HighRisk_i$ is a dummy variable equal to 1 if bank i was in the 6th sextile of the distribution of risk weighted assets over total assets in 2007. $LowL$ follows a similar definition using liquidity ratio instead. These two interaction terms are our two main variables of interest. We can test a similar hypothesis as in (17) for these two variables. The hypotheses we want to test is

$$\text{Hypothesis 2 } (H_2, \text{ Funding Cost}) : \alpha_{TAF} \leq \alpha_{DW} \text{ (for riskier and more liquid banks)}, \quad (19)$$

Table 3: Regressions for funding cost for years 2010 and 2007 considering the intensity of access to DW and TAF.

This table shows results of fixed effects regressions of funding cost by type of funding source where we control for the intensity of use of the DW or TAF. We use same regressors as the previous table. AmountDW and AmountTAF is measured as the log of the total amount borrowed in every liquidity facility in the pre-Lehman period as percent of total assets in 2007. Post= Dummy equal to one for the post-Lehman period (2010), and equal to zero for 2007. TARP= Dummy equal to 1 if bank was part of the TARP program.

	Total funding cost	Domestic deposits					Foreign deposits	Interbank borrowing	Subordin. debt	Other borrowing
		All deposits	Transaction accounts	Saving accounts	Time depos. (<100)	Time depos. (>100)				
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$DW_{pre} \times Post$	-0.00957***	-0.00376	0.0117***	-0.0161**	-0.00535	-0.0123	0.00440	-0.0347**	-0.0449	-0.0325***
	(0.00359)	(0.00354)	(0.00374)	(0.00730)	(0.00850)	(0.00857)	(0.0171)	(0.0148)	(0.0456)	(0.0107)
$TAF_{pre} \times Post$	-0.0296**	-0.0168	0.00463	-0.0451*	0.00864	-0.0115	-0.0809*	-0.107***	0.0449	-0.107**
	(0.0123)	(0.0152)	(0.0135)	(0.0247)	(0.0201)	(0.0312)	(0.0449)	(0.0293)	(0.0958)	(0.0442)
TARP	-0.0527***	-0.0574***	-0.0177*	-0.0763***	-0.0129	-0.0733***	0.147*	-0.000113	-0.187*	-0.0198
	(0.00503)	(0.00534)	(0.00908)	(0.00905)	(0.00977)	(0.0117)	(0.0837)	(0.0306)	(0.112)	(0.0203)
Asset (log)	0.0257***	0.0191*	0.0223***	-0.0431***	0.0596***	0.0401***	-0.204*	0.0155	0.0859	-0.0377
	(0.00829)	(0.0103)	(0.00749)	(0.0114)	(0.0106)	(0.0139)	(0.122)	(0.0324)	(0.119)	(0.0257)
ROA	-0.00830***	-0.00472**	-0.000684	-0.00399	0.00187	0.00173	-0.0385	0.0115	-0.00316	-0.00257
	(0.00241)	(0.00196)	(0.00127)	(0.00244)	(0.00293)	(0.00325)	(0.0537)	(0.0112)	(0.0177)	(0.00546)
Liquidity ratio	3.97e-07	1.87e-07	-6.76e-06***	0.000227*	-9.23e-05***	-3.60e-08	8.68e-05	9.61e-08	-2.38e-05	5.33e-07
	(3.62e-07)	(2.61e-07)	(8.67e-07)	(0.000131)	(1.08e-05)	(1.71e-07)	(8.58e-05)	(1.40e-06)	(1.68e-05)	(5.20e-07)
Sens. to market risk	-0.000430***	-0.000271*	-5.40e-06	0.00245***	3.07e-05	-0.000196	-0.00617***	0.00318***	-0.000354	-0.000211
	(0.000122)	(0.000157)	(0.000121)	(0.000173)	(0.000173)	(0.000224)	(0.00185)	(0.000669)	(0.00254)	(0.000521)
Chargeoffs	-0.00680***	-0.00418**	0.000311	-0.0139***	0.00246	0.00123	-0.0333	0.00278	-0.0255	-0.00202
	(0.00166)	(0.00198)	(0.00108)	(0.00207)	(0.00217)	(0.00326)	(0.0338)	(0.00738)	(0.0211)	(0.00515)
Funding mix	-7.69e-05***	-8.48e-05***	1.59e-05	-0.000883	-0.000125	-0.000135	0.0395	0.000166***	7.64e-05**	0.000394***
	(1.88e-05)	(2.17e-05)	(2.62e-05)	(0.00103)	(0.000104)	(0.000229)	(0.0402)	(1.55e-05)	(2.98e-05)	(8.14e-05)
High risk securities	0.000483	-0.000462	-0.00235	-0.00262*	0.000297	0.00258	0.0190*	-0.00834*	0.0378**	-0.000927
	(0.00126)	(0.000764)	(0.00152)	(0.00156)	(0.00114)	(0.00204)	(0.0108)	(0.00474)	(0.0183)	(0.00361)
Long term securities	0.00153***	0.00167***	0.000618***	0.00275***	0.000416	0.000628*	-0.00692	-8.06e-05	-0.00853	-0.00446***
	(0.000224)	(0.000207)	(0.000208)	(0.000316)	(0.000280)	(0.000353)	(0.00625)	(0.00132)	(0.00922)	(0.00107)
std. deviation ROA	-0.00979***	-0.00647***	-0.000236	0.000133	-0.00690**	-0.00254	-0.0117	0.000398	-0.00382	-0.00394
	(0.00236)	(0.00232)	(0.00183)	(0.00263)	(0.00299)	(0.00407)	(0.0226)	(0.0143)	(0.0204)	(0.00822)
Z-score	-4.61e-06***	-4.50e-06***	8.90e-07	-7.90e-06***	-5.83e-06*	-7.92e-06**	-0.000199***	2.46e-06	-0.000132	-3.04e-05***
	(1.36e-06)	(1.28e-06)	(1.87e-06)	(2.90e-06)	(3.17e-06)	(3.09e-06)	(5.53e-05)	(1.15e-05)	(8.61e-05)	(8.63e-06)
Bank age	-0.158***	-0.156***	-0.0357***	-0.114***	-0.214***	-0.229***	-0.285***	-0.263***	-0.110***	-0.0932***
	(0.000960)	(0.000952)	(0.00115)	(0.00154)	(0.00138)	(0.00165)	(0.0270)	(0.00625)	(0.0317)	(0.00400)
Other bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarterly fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	64,490	64,483	57,903	57,955	57,936	57,898	672	21,945	1,906	41,862
Number of banks	8,763	8,762	7,912	7,899	7,902	7,917	103	4,718	362	6,698
R squared	0.890	0.889	0.172	0.704	0.828	0.775	0.766	0.381	0.248	0.119
H_1 : Funding cost for DW banks in post Lehman period ($DW_{pre} \times Post$) $\leq$ Funding cost for TAF banks in post Lehman period ($TAF_{pre} \times Post$)										
15% significance	REJECT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT	REJECT	REJECT	ACCEPT	REJECT
10% significance	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	REJECT	ACCEPT	REJECT
5% significance	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	REJECT	ACCEPT	ACCEPT

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 shows the results of the estimates of this augmented model. We omit the the estimates corresponding to bank controls to simplify the exposition of the results. We find that our previous result that rejects Hypothesis 1 for the case of interbank borrowing rates is confirmed for the case of the high risk banks. It is interesting the fact that the difference in funding costs between TAF and DW banks is substantially larger (a difference of $45 + 12 = 57$ basis points) than the result obtained without interactions. Additionally, as we have shown in Table 1 a great majority of banks that failed after the failure of Lehman accessed the DW before the failure of Lehman.

In contrast, we do not find any significant effect when considering low liquidity banks. This is not a result that would be predicted by our model. A possible explanation to this result is the fact that liquidity is a variable that may be easier to adjust by banks in the short-run, whereas it is much harder to banks to adjust the level of the riskiness of their assets.

It could be argued that banks that used the DW were troubled banks that were forced to access the secondary window because they did not qualify for the primary window. However, as we have shown before in Figure 2b and Figure 4, most DW banks were considered as primary before the failure of Lehman, and therefore should be able to access the primary window if necessary. Gilbert *et al.* (2012) show that only few banks that failed during the period 2008-10 borrowed from the Fed during their last year prior to failure, and only a few had outstanding Fed loans when they failed. They also show that the Fed did not provide significant credit to undercapitalized or critically undercapitalized banks. In summary, the majority of banks that borrowed from the Fed and failed, used the DW. But this use was mainly done at the beginning of the crisis, in the pre-Lehman period, when some of these banks were not yet perceived as risky. This suggests that the access to the DW by banks affected the perceptions of the markets about banks in financial stress, which could have let to their default in a posterior period.

Finally, we also study how size interact with the results found so far. We consider an interaction term $Small$ which corresponds to banks that have less than 1 B assets. We would expect these banks more interested in signaling as their smaller size makes them more opaque. Also, they are not too-big-to-fail banks, and therefore may be subject to more scrutiny by funding markets. Table (4) shows the result of the effect of size. Confirming our intuition we find that the effect on funding costs is also substantially larger than we found before.

Table 4: Regressions for funding cost for years 2010 and 2007 (total and by type of funding source), including interaction effects with banks of different types (as in 2007).

This table shows results of fixed effects regressions of funding cost by type of funding source where we control for riskyness, size and liquidity of banks as measured in 2007. HighRisk=Dummy equal to 1 if the bank is in the highest sextile of the distribution of the ratio of risk weighted assets over assets. LowL= Dummy equal to 1 if the bank is in the lowest sextile of the distribution of liquidity risk. Small= Dummy equal to one if the bank has less than 1 B assets.

	Total	Domestic deposits					Foreign	Interbank	Subordin.	Other
	funding	All	Transaction	Saving	Time depos.	Time depos.	deposits	borrowing	debt	borrowing
	cost	deposits	accounts	accounts	(<100)	(>100)				
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$DW_{pre} \times Post$	-0.0299*	-0.00151	-0.0348	0.0440	0.0171	-0.132**	-0.0550	-0.0345	0.103	-0.0405
	(0.0161)	(0.0148)	(0.0429)	(0.0316)	(0.0326)	(0.0615)	(0.0852)	(0.0670)	(0.160)	(0.0525)
$TAF_{pre} \times Post$	-0.120***	-0.100**	0.0109	-0.0971	-0.00287	-0.152*	-0.183*	-0.0355	-0.388	-0.157
	(0.0271)	(0.0435)	(0.0565)	(0.0951)	(0.0724)	(0.0784)	(0.106)	(0.133)	(0.240)	(0.138)
$DW_{pre} \times Post \times HighRisk$	-0.0565***	-0.0609***	0.0146	-0.0865***	0.0433	-0.132***	-0.277**	0.129*	0.307	-0.0301
	(0.0156)	(0.0149)	(0.0302)	(0.0277)	(0.0322)	(0.0494)	(0.116)	(0.0754)	(0.423)	(0.0568)
$TAF_{pre} \times Post \times HighRisk$	-0.00872	-0.0459	0.142	0.0559	-0.0103	0.149	-0.333	-0.451***	0.215	-0.285
	(0.0451)	(0.0735)	(0.0966)	(0.0830)	(0.101)	(0.143)	(0.228)	(0.130)	(0.284)	(0.278)
$DW_{pre} \times Post \times LowL$	-0.0588***	-0.0879***	-0.0195	-0.117***	0.0707	-0.0329	0.179	0.0364	-0.892**	0.0486
	(0.0188)	(0.0177)	(0.0331)	(0.0395)	(0.0446)	(0.0739)	(0.126)	(0.0761)	(0.388)	(0.0583)
$TAF_{pre} \times Post \times LowL$	0.0443	0.0167	-0.00191	0.152*	-0.0103	0.232	0.390***	0.0741	1.107**	0.0648
	(0.0480)	(0.0636)	(0.0665)	(0.0885)	(0.0932)	(0.169)	(0.0940)	(0.209)	(0.435)	(0.165)
$DW_{pre} \times Post \times Small$	0.0365**	0.0162	0.0237	-0.0388	-0.0418	0.128**		-0.0633	-0.102	-0.0115
	(0.0168)	(0.0154)	(0.0395)	(0.0316)	(0.0360)	(0.0580)		(0.0716)	(0.357)	(0.0559)
$TAF_{pre} \times Post \times Small$	0.0421	0.154**	-0.185	-0.00511	-0.0664	-0.276		-0.316**		0.344*
	(0.0615)	(0.0691)	(0.158)	(0.0781)	(0.113)	(0.190)		(0.140)		(0.200)
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarterly fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	63,999	63,992	57,464	57,517	57,497	57,452	672	21,866	1,902	41,680
Number of banks	8,639	8,638	7,801	7,789	7,791	7,805	103	4,688	361	6,643
R squared	0.891	0.890	0.173	0.705	0.829	0.777	0.776	0.381	0.275	0.118
H_1 : Cost for DW banks in post Lehman period ($DW_{pre} \times Post$) $\leq$ Cost for TAF banks in post Lehman period ($TAF_{pre} \times Post$)										
15% significance	REJECT	REJECT	ACCEPT	REJECT	ACCEPT	ACCEPT	REJECT	ACCEPT	REJECT	ACCEPT
10% significance	REJECT	REJECT	ACCEPT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT
5% significance	REJECT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT
H_1 : Cost for small DW banks in post Lehman period ($DW_{pre} \times Post \times Small$) $\leq$ Cost for small TAF banks in post Lehman period ($TAF_{pre} \times Post \times Small$)										
15% significance	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT	REJECT	ACCEPT	REJECT	ACCEPT	ACCEPT
10% significance	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	REJECT	ACCEPT	ACCEPT
5% significance	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT
H_2 : Cost for high risk DW banks in post Lehman period ($DW_{pre} \times Post \times HighRisk$) $\leq$ Cost for high risk TAF banks in post Lehman period ($TAF_{pre} \times Post \times HighRisk$)										
15% significance	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT
10% significance	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT
5% significance	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT
H_2 : Cost for low liq. DW banks in post Lehman period ($DW_{pre} \times Post \times LowL$) $\leq$ Cost for low liq. TAF banks in post Lehman period ($TAF_{pre} \times Post \times LowL$)										
15% significance	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT
10% significance	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT
5% significance	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5 Extensions

5.1 Matched sample analysis

As a robustness check, we can provide an alternative specification to the model in (16) by using a matching method combined with bank-level fixed effects (see Lemmon and Roberts, 2010; Duchin and Sosyura, 2014, among others). We use the propensity score to match the banks that accessed the DW or the TAF in the pre-Lehman period to the banks that did not access any facility. This allow us to select banks that are similar in 2007 based on the observed variables of control. Then, we can use these matched observations in a fixed effect model as in (16). This method provides a robustness check of our baseline model and provides a number of advantages. First, the matching estimator helps relaxing the linearity assumption existing between funding cost/sources of funding and bank characteristics. Using the fixed effects estimator helps eliminating selection bias due to unobservable time invariant bank effects. This methodology can also alleviate potential concerns over the violation of the unconfoundedness assumption of the traditional propensity score matching model (see Lemmon and Roberts, 2010; Roberts and Whited, 2012).

In the first stage of this method we do a matching of covariates using a propensity score. We separately match banks that have not been in TAF or the DW in the pre-Lehman period with DW and TAF banks. We use a logit probabilistic model to find the score of every sample and use similar control variables as in the baseline model. Table C.2 shows the quality of the match. We test differences between means of covariates for treated and matched samples to show the quality of the match. Matched samples are observationally equivalent for a relatively high level of significance for most covariates.

Table C.3 shows the fixed effect regression for matched samples for the case of funding cost. We find similar results as found previously in Table 2. Difference in funding cost for interbank borrowing of TAF banks with respect to DW banks decreases to about 15 bsp compared to the baseline model, but the difference is significant at a 10% significance level. Differences in terms of total funding cost decreases to about 4 bsp compared to the baseline model.

5.2 Endogenous treatment effect

Estimation of baseline model in (16) can be affected by biases due to the potential endogeneity of variables $DW_{i,pre}$ and $TAF_{i,pre}$. We follow the dummy-endogenous variable literature (Heckman, 1978) and use a two-step procedure where in a first step we run a probit regression for the choice of using TAF or DW by banks using the previous bank controls and an instrumental variable as regressors. In the second step, we augment our objective regression with the hazard rates calculated from the first stage. This method has been used in a similar context for TARP by Berger and Roman (2014) and Duchin and Sosyura (2014). The use of an appropriate instrument is the key identifying assumption. The instrumental variable that we use is presence in the board of directors of a Federal Reserve District. This instrument has been used by Bayazitova and Shivdasani (2012), Li (2013) and Berger and Roman (2014) to instrument access to TARP.

Each of the 12 Reserve Banks is subject to the supervision of a nine member board of directors. Six of the directors are elected by the member banks of the respective Federal Reserve District, and three of the directors are appointed by the Board of Governors. Some of the directors appointed by the Board of Governors are executives of firms not related with the banking industry, with interests in the agriculture, commerce, or other sectors. The rest of the directors are usually top-executives of banks. The Board of the Fed expects from these directors to have a good understanding of the economic conditions of their district and the economy as a whole, and to be respected individuals in their community and able to meet their financial obligations.[21]

Directors play an important role in the effective functioning of the Federal Reserve and participate in the formulation of monetary policy. In addition, they are responsible for supervising the administration of their Reserve Bank's operations or overseeing the Reserve Bank's corporate governance function. However, directors are not involved in any matters related to banking supervision, including specific supervisory decisions.[22] Banks that are part of the board of the Fed System could have an advantage to obtain useful information about accessing the DW and TAF. Therefore being a Board member may be positively or negatively correlated with the access to these facilities. However, because members of the Board are elected by the district banks and because

[21] http://www.federalreserve.gov/generalinfo/listdirectors/PDF/eligibility-qualifications-rotation.pdf

[22] For more information, see http://www.federalreserve.gov/aboutthefed/directors/about.htm

of the required qualifications, it is reasonable to conjecture that a bank's Board membership is not directly related to a bank's funding cost. Winning candidates may be specially well connected with their colleagues in other banks and should be regarded to have the skills and qualifications for the position. All these factors should not be directly related with funding cost. Therefore, Board membership a good instrument for our purpose.

In Table C.4 we show the results of the first stage probit regression. Controlling for all the other bank level variables, we find that banks that are part of the Board are less likely to access these two facilities. One interpretation that we give to this result is that banks that are members of the Board are better informed about these liquidity facilities and prefer to access alternative sources of funding. Another interpretation is that since these banks have a direct role as supervisors and overseers of the Reserve Banks, they may prefer to avoid the use of these facilities, whose access could potentially create a conflict of interest.

In Table C.5 we show the results from the second stage regressions. We do not obtain significant differences from the baseline specification. Effects for total funding cost are very similar to the previous case, whereas the effect for interbank borrowing is smaller, but we still find a difference of about 18 bps between TAF and DW banks.

5.3 Effect on funding structure

We next study the changes in the structure of funding by DW and TAF banks in the post-Lehman period. This analysis complements the results on the cost of funding obtained in previous sections, and helps to understand better the effect of using these two liquidity facilities on the banks' liabilities. The use of wholesale funds can be a good indicator of markets' perception of its financial soundness. A large literature that tries to explain the role of wholesale funds and its increasing use during the last decades (Feldman and Schmidt, 2001) emphasizes that these funds are less stable than the traditional insured retail deposits, and therefore are considered to provide market discipline to banks (Calomiris, 1999). Wholesale funding is provided by sophisticated financiers who discipline bad banks through monitoring and refinance solvent ones (Calomiris and Kahn, 1991). Showing evidence of a relationship between banks' usage of wholesale funding in the second period, and their decision to borrow from the DW or TAF is a relevant empirical exercise that can provide some evidence of the "signaling effect" in our model.

Our stylized model provides testable results on funding rates but not on quantities. We would expect that TAF banks would use more certain types of funding that are more sensitive to the perceived quality of banks. We estimate a similar equation to (16) where we consider different sources of funding measured as fraction of total liabilities:

$$\text{SourceFunding}_{i,t} = \beta_{TAF} TAF_{i,pre} \times Post_t + \beta_{DW} DW_{i,pre} \times Post_t + \beta_X X_{i,t} + c_t + \mu_i + \xi_{i,t}, \quad (20)$$

where $\text{SourceFunding}_{i,t}$ is the percent of a certain type of source of funding over total liabilities. We use similar controls as in model (16). Our variables of interest are β_{TAF} and β_{DW}. Our objective is to understand in what types of funding TAF banks tend to depend more in the post-Lehman period compared to DW banks. Therefore, we want to focus on the sources of funding where we can to reject the following hypothesis:

$$\text{Hypothesis 3 } (H_3, \text{ Sources of Funding}) : \beta_{TAF} \leq \beta_{DW}. \quad (21)$$

Table 5 show results of the estimates of model (20) for relative amounts of funding by type. We use the amount of wholesale funding (as a fraction of total liabilities), a more narrow definition of wholesale funding, and also we use more specific sources of funding (domestic deposits, savings accounts, transaction accounts, time deposits, foreign deposits, interbank borrowing, subordinated debt and other borrowing).

In line with the prediction of our model that accessing the TAF signals quality we find that TAF banks are able to attract more deposits than DW banks during the financial crisis, which is consistent with a large literature on depositor discipline (see e.g. Goldberg and Hudgins, 2002; Park and Peristiani, 1998; Oliveira *et al.*, 2014). Most of that increase comes from savings accounts.

Table 5: Regressions of sources of funding for years 2010 and 2007 (total and by type of funding source).

This table shows results of fixed effect regressions of different sources of funding (as a % of total liabilities) between 2010 and 2007. Wholesale funding in (1); wholesale funding (narrow definition) in (2); domestic deposits in (3); transaction accounts in (4); savings accounts in (5); time deposits of less than 100,000 USD in (6); time deposits of more than 100,000 USD in (7); foreign deposits in (8); interbank borrowing in (9); subordinated debt in (10); and other liabilities in (11). DW= Dummy equal to 1 if bank was DW mainly in the pre-Lehman period. TAF= Dummy equal to 1 if bank was TAF mainly in the pre-Lehman period. Post= Dummy equal to one for the post-Lehman period (2010), and equal to zero for 2007. TARP= Dummy equal to 1 if bank was part of the TARP program.

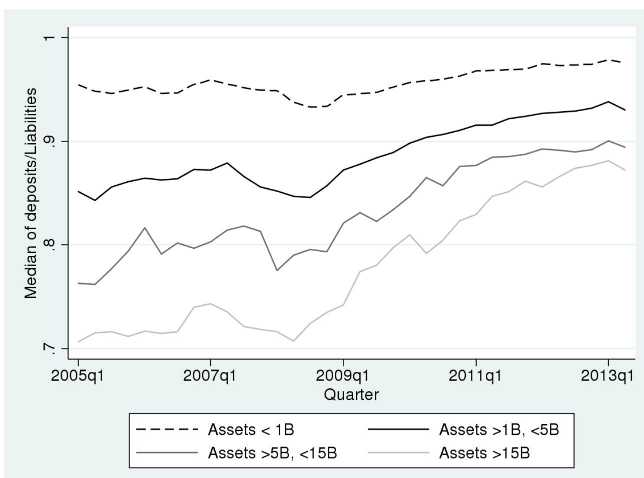
	Wholesale funding	Wholesale funding narrow	Domestic deposits					Foreign deposits	Interbank borrowing	Subordin. debt	Other borrowing
			All deposits	Transaction accounts	Saving accounts	Time depos. (<100)	Time depos. (>100)				
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$DW_{pre} \times Post$	-2.738***	-2.126***	0.897**	0.268	0.198	1.627***	-1.219**	-0.0765	-0.325	-0.00931	-0.585**
	(0.613)	(0.614)	(0.354)	(0.395)	(0.573)	(0.566)	(0.479)	(0.0671)	(0.225)	(0.0153)	(0.285)
$TAF_{pre} \times Post$	-1.568	-0.202	5.957**	1.559	4.070**	3.449***	-2.993*	0.196	-3.991**	-0.389**	-0.984
	(2.632)	(2.439)	(2.832)	(1.009)	(1.715)	(0.986)	(1.761)	(0.745)	(1.970)	(0.198)	(2.406)
TARP	-2.208***	-1.775***	0.757***	-0.0970	1.218***	0.183	-0.684**	-0.0626	-0.383**	0.00514	-0.432*
	(0.426)	(0.415)	(0.286)	(0.322)	(0.414)	(0.361)	(0.347)	(0.0526)	(0.177)	(0.0140)	(0.232)
Asset (log)	1.308**	-1.612**	-2.012***	-3.503***	-0.271	1.373***	0.963*	0.0861	-0.347	0.0162	2.895***
	(0.563)	(0.648)	(0.543)	(0.426)	(0.590)	(0.493)	(0.556)	(0.0718)	(0.264)	(0.0117)	(0.539)
ROA	-0.289**	-0.0966	0.128	0.137	-0.134	-0.144	0.216**	-0.00671	-0.0497*	0.000673	-0.191*
	(0.129)	(0.132)	(0.0788)	(0.0968)	(0.104)	(0.101)	(0.0972)	(0.00879)	(0.0283)	(0.00172)	(0.114)
Liquidity ratio	3.15e-05	5.69e-06	-3.11e-05	4.19e-06*	-2.43e-05	-9.58e-06	-9.76e-07	7.59e-09	4.25e-06	-1.67e-07	2.60e-05
	(2.94e-05)	(1.44e-05)	(4.15e-05)	(2.48e-06)	(4.07e-05)	(7.34e-06)	(2.98e-06)	(1.51e-07)	(1.98e-05)	(2.39e-07)	(3.00e-05)
Sens. to market risk	0.119***	0.147***	0.0584***	0.0364***	0.139***	-0.0544***	-0.0515***	-0.00153	-0.0299***	0.000377	-0.0283***
	(0.00896)	(0.00975)	(0.00799)	(0.00751)	(0.00838)	(0.00717)	(0.00864)	(0.00130)	(0.00379)	(0.000474)	(0.00730)
Chargeoffs	-0.727***	-0.657***	0.263***	-0.00373	-0.121	0.292***	0.0697	0.00846	-0.183***	-0.00199	-0.0665
	(0.0938)	(0.104)	(0.0990)	(0.0641)	(0.0834)	(0.0772)	(0.0943)	(0.0133)	(0.0454)	(0.00264)	(0.0928)
Funding mix	0.00509*	0.00487*	-0.000324	0.000323**	-0.000933***	0.00247	-0.00223	-6.45e-06	0.000238**	-0.000125	0.000345
	(0.00296)	(0.00286)	(0.000406)	(0.000139)	(0.000344)	(0.00184)	(0.00189)	(2.01e-05)	(9.83e-05)	(0.000159)	(0.000497)
High risk securities	0.0494	0.0150	-0.00851	-0.0101	0.0665	-0.0629	-0.00517	0.00581*	-0.0312**	0.00113	0.0326
	(0.0556)	(0.0570)	(0.0314)	(0.0369)	(0.0678)	(0.0622)	(0.0376)	(0.00332)	(0.0156)	(0.00142)	(0.0268)
Long term securities	0.112***	0.0979***	-0.0303***	-0.0258**	0.0387***	-0.0439***	-0.00456	0.000549	0.0143***	-0.000293	0.0147*
	(0.0145)	(0.0135)	(0.00918)	(0.0109)	(0.0131)	(0.0106)	(0.0109)	(0.000835)	(0.00470)	(0.000234)	(0.00812)
std. deviation ROA	-0.260*	-0.116	0.0987	0.0401	0.0359	0.101	0.0187	-0.0141	-0.0770	-0.00380	-0.137*
	(0.142)	(0.136)	(0.0886)	(0.0951)	(0.120)	(0.120)	(0.129)	(0.00957)	(0.0547)	(0.00300)	(0.0791)
Z-score	-0.000347	-0.000444**	-1.84e-05	0.000186***	-0.000131*	-2.79e-05	-2.16e-05	-2.23e-06	-9.21e-05*	-1.93e-06	1.00e-04**
	(0.000217)	(0.000219)	(6.74e-05)	(6.54e-05)	(7.70e-05)	(9.14e-05)	(6.86e-05)	(4.68e-06)	(4.80e-05)	(2.41e-06)	(4.26e-05)
Bank age	-3.355***	-2.887***	0.588***	0.641***	1.493***	-1.735***	0.300***	-0.0153	-0.108***	-0.00112	-0.466***
	(0.0667)	(0.0673)	(0.0478)	(0.0470)	(0.0612)	(0.0515)	(0.0533)	(0.0103)	(0.0278)	(0.00192)	(0.0455)
Other bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarterly fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	64,598	64,586	64,627	64,627	64,627	58,548	64,627	64,627	64,625	64,627	64,627
Number of banks	8,763	8,763	8,763	8,763	8,763	7,960	8,763	8,763	8,763	8,763	8,763
R squared	0.497	0.489	0.0710	0.0427	0.119	0.168	0.0388	0.00190	0.0424	0.00589	0.0511
H_3 : Funding for TAF banks in post Lehman period ($TAF_{pre} \times Post$) $\leq$ Funding for DW banks in post Lehman period ($DW_{pre} \times Post$)											
15% significance	ACCEPT	ACCEPT	REJECT	REJECT	REJECT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT
10% significance	ACCEPT	ACCEPT	REJECT	ACCEPT	REJECT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT
5% significance	ACCEPT	ACCEPT	REJECT	ACCEPT	REJECT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We also observe a shift from larger term deposits (above $100.000) to smaller term deposits.[23] We do not find a significant difference for transaction accounts which is consistent with the introduction of the Transaction Account Guarantee Program (TAGP) by the FDIC on October 14, 2008. This program guaranteed in full all domestic noninterest-bearing transaction deposits and low-interest negotiable order of withdrawal (NOW) accounts until December 2012.

There is usually a greater use of retail deposits during crisis periods due to explicit and implicit government guarantees, which insulate banks from liquidity risks (Gatev and Strahan, 2006; Cornett *et al.*, 2011). Figure 9 shows a very clear trend towards a greater use of retail deposits for banks of different sizes. Acharya and Mora (2015) also show a similar trend for the post-Lehman period of the recent financial crisis. Deposits are attractive for banks because they usually offer a more stable and less expensive source of funding than wholesale funds. In addition, there was probably a greater demand of insured deposits by investors, reflecting a flight to safety out of more risky investment instruments during the post-Lehman period.

Figure 9: Use of deposits by U.S. commercial banks



We can reconcile the previous results on funding cost with the obtained results in the structure of funding. We found previously that TAF banks pay a lower rate than DW banks in the interbank lending market, but we could not find a statistically different effect for other types of sources of funding, such as deposits. The findings in this subsection imply that TAF banks were able to

[23] During normal times we would interpret such a shift as an increase of insured deposits at the expense of uninsured deposits as the deposit insurance limit is $100.000 in the US. However on October 3, 2008 the deposit insurance limit was temporarily raised to $250.000 until December 2009 through the Emergency Economic Stabilization Act of 2008. We therefore do not have a good interpretation for this shift in the granularity of time deposits.

expand their usage of savings accounts and smaller time deposits without significantly changing the rates paid. Depositors seem to be less price elastic, which is particularly true for deposits such as current accounts, which provide customers with a safe place to keep their savings and the option to withdraw cash or make electronic payments. On the contrary, lenders and borrowers in the interbank lending market collect more information regarding their counter parties and therefore, their rates paid are more likely to be affected by the perceived quality of their counter parties.

6 Conclusion

In this paper, we have discussed the importance of the TAF liquidity facility to help banks to signal themselves as financially sound during the recent financial crisis. We show that a 'one size fits all'-approach with respect to LOLR policy is not useful. In addition, the characteristics of these facilities have relevant implications. A fully flexible TAF would not be very helpful for banks to signal themselves as financially sound because it would be equivalent to the DW and separation would not be costly.

We also provide empirical evidence that the choices made by banks in the period of financial turbulence have posterior consequences in terms of cost of funding, access to wholesale markets, and perceived riskiness. We use several econometric specifications that are in general robust to the predictions we expect from our model.

Our results will contribute to understand better the functioning of financial markets during the recent financial crisis, and the importance of an appropriate design of liquidity facilities in periods of high asymmetric information. Aspects that are non favorable for banks, such as lack of flexibility of certain liquidity facilities, are crucial because they can be used by sound financial institutions to separate themselves from banks that are in worse financial conditions.

References

Acharya, V. and Backus, D. (2009). Private lessons for public banking: The case for conditionality in LOLR facilities. *Financial Markets, Institutions and Instruments*, **18** (2), 176.

Acharya, V. V., Gromb, D. and Yorulmazer, T. (2012). Imperfect competition in the interbank market for liquidity as a rationale for central banking. *American Economic Journal: Macroeconomics*, **4** (2), 184–217.

— and Mora, N. (2015). A crisis of banks as liquidity providers. *The Journal of Finance*, **70** (1), 1–43.

— and Tuckman, B. (2013). Unintended consequences of LOLR facilities: The case of illiquid leverage. *Working Paper, New York University*.

Afonso, G., Kovner, A. and Schoar, A. (2011). Stressed, not frozen: The Federal Funds market in the financial crisis. *The Journal of Finance*, **66** (4), 1109–1139.

Armantier, O., Ghysels, E., Sarkar, A. and Shrader, J. (2011). Stigma in financial markets: Evidence from liquidity auctions and discount window borrowing during the crisis. *FRB of New York Staff Report*, (483).

—, Krieger, S. and McAndrews, J. (2008). The Federal Reserve's Term Auction Facility. *Current Issues in Economics and Finance*, **14** (5).

Bagehot, W. (1878). *Lombard Street: a description of the money market*. C. Kegan Paul.

Bayazitova, D. and Shivdasani, A. (2012). Assessing TARP. *Review of Financial Studies*, **25** (2), 377–407.

Benmelech, E. (2012). An empirical analysis of the Fed's Term Auction Facility. *Wroking Paper, National Bureau of Economic Research*.

Berger, A. N., Black, L. K., Bouwman, C. H. and Dlugosz, J. (2014). The Federal Reserve's Discount Window and TAF programs: Pushing on a string? *Working Paper, Darla Moore School of Business, University of South Carolina*.

— and Roman, R. A. (2014). Did Saving Wall Street Really Save Main Street? The Real Effects of TARP on Local Economic Conditions. *Working Paper, Darla Moore School of Business, University of South Carolina*.

Bernanke, B. (2009). The Federal Reserve's balance sheet: An update. In *Speech at the Federal Reserve Board Conference on Key Developments in Monetary Policy, Washington, DC*, vol. 8.

Bouvard, M., Chaigneau, P. and Motta, A. d. (2015). Transparency in the financial system: Rollover risk and crises. *The Journal of Finance*, **70** (4), 1805–1837.

Calomiris, C. W. (1999). Building an incentive-compatible safety net. *Journal of Banking & Finance*, **23** (10), 1499–1519.

— and Kahn, C. M. (1991). The role of demandable debt in structuring optimal banking arrangements. *The American Economic Review*, pp. 497–513.

Cecchetti, S. G. (2009). Crisis and responses: the Federal Reserve in the early stages of the financial crisis. *The Journal of Economic Perspectives*, **23** (1), 51–76.

Cornett, M. M., McNutt, J. J., Strahan, P. E. and Tehranian, H. (2011). Liquidity risk management and credit supply in the financial crisis. *Journal of Financial Economics*, **101** (2), 297–312.

Courtois, R. and Ennis, H. M. (2010). Is there stigma associated with discount window borrowing? *Richmond Fed Economic Brief*, (May).

Diamond, D. W. and Rajan, R. G. (2005). Liquidity shortages and banking crises. *The Journal of Finance*, **60** (2), 615–647.

Drechsler, I., Drechsel, T., Marques-Ibanez, D. and Schnabl, P. (2013). Who borrows from the Lender of Last Resort? *Working Paper, New York University.*

Duchin, R. and Sosyura, D. (2014). Safer ratios, riskier portfolios: Banks' response to government aid. *Journal of Financial Economics*, **113** (1), 1–28.

Ennis, H. M. and Weinberg, J. A. (2013). Over-the-counter loans, adverse selection, and stigma in the interbank market. *Review of Economic Dynamics*, **16** (4), 601–616.

Feldman, R. and Schmidt, J. (2001). Increased use of uninsured deposits. *Fedgazette*, (Mar), 18–19.

Fleming, M. (2011). Federal Reserve liquidity provision during the financial crisis of 2007–2009. *Annual Review of Financial Economics*, **4**, 161–177.

Furfine, C. (2001). The reluctance to borrow from the Fed. *Economics Letters*, **72** (2), 209–213.

— (2005). Discount window borrowing: Understanding recent experience. *Chicago Fed Letter*, **212**.

Gatev, E. and Strahan, P. E. (2006). Banks' advantage in hedging liquidity risk: Theory and evidence from the commercial paper market. *The Journal of Finance*, **61** (2), 867–892.

Gilbert, R. A., Kliesen, K., Meyer, A. and Wheelock, D. (2012). Federal Reserve lending to troubled banks during the financial crisis, 2007-10. *Federal Reserve Bank of St. Louis Working Paper.*

Goldberg, L. G. and Hudgins, S. C. (2002). Depositor discipline and changing strategies for regulating thrift institutions. *Journal of Financial Economics*, **63** (2), 263–274.

Goldstein, I. and Leitner, Y. (2015). Stress tests and information disclosure.

Goulding, W. and Nolle, D. (2012). Foreign banks in the US: A primer. *FRB International Finance Discussion Paper*, (1064r).

Heckman, J. J. (1978). Dummy endogenous variables in a simultaneous equation system. *Econometrica*, **46** (4), 931–959.

Klee, E. (2011). The first line of defense: The discount window during the early stages of the financial crisis. *Working Paper, Federal Reserve Board of Governors.*

Lemmon, M. and Roberts, M. R. (2010). The response of corporate financing and investment to changes in the supply of credit. *Journal of Financial and Quantitative Analysis*, **45** (03), 555–587.

Li, L. (2013). TARP funds distribution and bank loan supply. *Journal of Banking & Finance*, **37** (12), 4777–4792.

Oliveira, R. d. F., Schiozer, R. F. and Barros, L. A. d. C. (2014). Depositors' perception of "too-big-to-fail". *Review of Finance*, p. rft057.

Park, S. and Peristiani, S. (1998). Market discipline by thrift depositors. *Journal of Money, Credit and Banking*, pp. 347–364.

Peristiani, S. (1998). The growing reluctance to borrow at the discount window: An empirical investigation. *Review of Economics and Statistics*, **80** (4), 611–620.

Puddu, S. and Wälchli, A. (2012). TAF effect on liquidity risk exposure. *Working Paper, University of Neuchâtel*.

Roberts, M. R. and Whited, T. M. (2012). Endogeneity in empirical corporate finance. *Working Paper, William E. Simon Graduate School of Business Administration, University of Rochester*.

Rochet, J. and Vives, X. (2004). Coordination failures and the lender of last resort: Was Bagehot right after all? *Journal of the European Economic Association*, **2** (6), 1116–1147.

Sengupta, R. and Tam, Y. M. (2008). The LIBOR-OIS spread as a summary indicator. *Monetary Trends*, (Nov).

Taylor, J. B. and Williams, J. C. (2009). A black swan in the money market. *American Economic Journal: Macroeconomics*, **1** (1), 58–83.

Wu, T. (2008). On the effectiveness of the Federal Reserve's new liquidity facilities. *Working Paper, Federal Reserve Bank of Dallas*, (2008-08).

A The Discount Window before the crisis

Sound DI facing liquidity shortages can borrow from the Fed's primary lending facility —the discount window— at the 'primary lending rate'.[24] Before 2003, the discount rate was set below the target federal funds rate, which made the borrowing from the Fed cheaper than borrowing on the interbank market, and created potential arbitrage opportunities.[25] Accordingly, DIs were required to show that they exhausted private sources of funding and that they really need funds for their business purposes, on top of the regular scrutiny of their soundness. This additional requirement seems to have created a perception of stigma associated with DW borrowing as it might signal a financial weakness of the borrower if it became known to both peers and the Fed. These concerns may have deterred sound DIs with liquidity shortage from borrowing at the DW even if its terms and amounts were not made public. [26]

To address concerns about DW stigma, the Fed changed its approach to DW lending in 2003. It had put in place a penalty-rate regime, and classified DW loans into primary and secondary credit. Primary credit, the DW main source of short-term liquidity, is available on a "no-questions asked" basis to financially sound DIs that meet a certain capital threshold. These institutions pay the primary credit rate which was originally set to 100 basis points above the target federal fund rate. Secondary credit is available to DIs not eligible for primary credit, and entails a higher level of administrative burden. At the outset of program, secondary credit rate was 150 basis points above the Fed's target.

[24] Primary lending rate is more commonly known as the 'discount rate'. Prior to the recent financial crisis, DW operations were the Fed's primary means to implements its lender-of-last-resort function. Lending through the DW allows DIs to borrow against collateral that is not accepted elsewhere. The Fed would accept virtually anything as collateral, including U.S. Treasury securities, state and local government securities, AAA-rated collateralized mortgage obligations, consumer loans, commercial and agricultural loans, and investment-grade certificates of deposits. In some cases, the Fed accepted even the bank's buildings and furniture (Cecchetti (2009)).

[25] Banks could re-lend cheap DW funds on the interbank market at higher rates, potentially leading to larger reserves and lower rates than levels targeted by the Fed's monetary policy (Courtois and Ennis (2010)).

[26] DW stigma and associated banks' reluctance does not necessarily make DW useless. Acharya *et al.* (2012) show that stigma effects rather limit the surplus banks can squeeze out of needy banks.

Table A.1: Summary Statistics for Banks that are DW mainly or TAF mainly

	mean	sd	min	p1	p25	p50	p75	p90	p99	max	N
Before Lehman, DW mainly: Borrowers/Day	29	35	1	1	16	22	29	38	197	209	160
Before Lehman, DW mainly: Amount (millions)	660	2,901	0	0	5	32	148	617	14,200	44,110	4,617
Before Lehman, DW mainly: Term (days)	17	42	0	1	1	1	14	56	140	729	4,617
Before Lehman, DW mainly: Access Frequency	12	63	1	1	1	2	6	22	154	1,156	387
After Lehman, DW mainly: Borrowers/Day	55	20	15	16	40	54	67	83	107	118	337
After Lehman, DW mainly: Amount (millions)	926	3,872	0	0	3	9	37	600	23,500	61,000	18,444
After Lehman, DW mainly: Term (days)	11	68	0	1	1	1	3	27	93	1,753	18,444
After Lehman, DW mainly: Access Frequency	21	114	1	1	1	3	10	48	188	3,097	899
Before Lehman, TAF mainly: Borrowers/Day	17	8	5	5	12	16	23	25	32	32	21
Before Lehman, TAF mainly: Amount (millions)	832	1,356	5	5	50	150	1,000	3,000	5,000	7,500	348
Before Lehman, TAF mainly: Term (days)	31	11	28	28	28	28	28	28	84	84	348
Before Lehman, TAF mainly: Access Frequency	7	5	1	1	2	6	10	16	19	19	48
After Lehman, TAF mainly: Borrowers/Day	9	5	1	1	4	9	11	18	20	20	37
After Lehman, TAF mainly: Amount (millions)	1,349	2,592	5	5	60	250	1,500	3,500	15,000	15,000	331
After Lehman, TAF mainly: Term (days)	56	28	13	17	28	70	84	84	85	85	331
After Lehman, TAF mainly: Access Frequency	8	7	1	1	3	6	12	18	28	28	39

NOTE: We show key statistics for banks that accessed DW mainly and banks that accessed TAF mainly. We show statistics for the before-Lehman and after-Lehman periods.

B Proofs of theory model

B.1 Proof of Lemma 2

We know $r_2(\xi) = \frac{\theta(1-\xi)}{\theta\xi-\theta+1}$ and $\xi_0 = \frac{\alpha}{\alpha+(1-\alpha)(1-\rho)}$. Note that

$$\frac{\partial \xi_0}{\partial \alpha} = \frac{\alpha + (1-\alpha)(1-\rho) - (1-1+\rho)\alpha}{[\alpha + (1-\alpha)(1-\rho)]^2} = \frac{1-\rho}{[\alpha + (1-\alpha)(1-\rho)]^2} > 0 \tag{22}$$

$$\frac{\partial \xi_0}{\partial \rho} = \frac{\alpha(1-\alpha)}{[\alpha + (1-\alpha)(1-\rho)]^2} > 0. \tag{23}$$

Note that $r_2(\xi)$ is increasing in θ:

$$\begin{aligned} \frac{\partial r_2}{\partial \theta} &= \frac{(1-\xi)(\theta\xi - \theta + 1) - (\xi - 1)(\theta - \theta\xi)}{(\theta\xi - \theta + 1)^2} = \\ &= \frac{(1-\xi)}{(\theta\xi - \theta + 1)^2} > 0, \end{aligned} \tag{24}$$

which is intuitive: If θ increases, the probability of having a bad outcome is higher, and therefore the risk premium increases. We can also obtain the cross partial derivative:

$$\begin{aligned} \frac{\partial^2 r_2}{\partial \theta \partial \xi} &= \frac{-(\theta\xi - \theta + 1)^2 - 2(\theta\xi - \theta + 1)\theta(1-\xi)}{(\theta\xi - \theta + 1)^4} \\ &= \frac{(\theta\xi - \theta + 1)[-(\theta\xi - \theta + 1) - 2\theta(1-\xi)]}{(\theta\xi - \theta + 1)^4} < 0. \end{aligned} \tag{25}$$

Also we can show that $r_2(\xi)$ is increasing in ξ:

$$\begin{aligned} \frac{\partial r_2}{\partial \xi} &= \frac{-\theta(\theta\xi - \theta + 1) - \theta(\theta - \theta\xi)}{(\theta\xi - \theta + 1)^2} = \\ &= \frac{-\theta}{(\theta\xi - \theta + 1)^2} < 0. \end{aligned} \tag{26}$$

Therefore, we obtain the following comparative statics

$$\frac{dr_2(\xi = \xi_0)}{d\alpha} = \frac{\partial r_2(\xi = \xi_0)}{\partial \xi} \frac{\partial \xi_0}{\partial \alpha} < 0 \tag{27}$$

$$\frac{dr_2(\xi = \xi_0)}{d\rho} = \frac{\partial r_2(\xi = \xi_0)}{\partial \xi} \frac{\partial \xi_0}{\partial \rho} < 0 \tag{28}$$

$$\frac{dr_2(\xi = \xi_0)}{d\theta} = \frac{\partial r_2(\xi = \xi_0)}{\partial \theta} > 0. \tag{29}$$

B.2 Proof of Proposition 2

In Figure 6 it is easy to see that when r_d is small enough, then the equilibrium region for r_t is such that $r_t > r_d$.

In order to find comparative statics results of the equilibrium rates with respect to α, ρ and θ, we need to study how the equilibrium region defined by (10) and (15) changes with these parameters. The equilibrium conditions can be written as $r_t \leq r_d + I_2$ and $r_t \geq \rho r_d + I_1$. We find a simple expression for the intercept of (15), $I_1 \equiv \rho r_2(0) + (1-\rho) r_2(\xi_0) - r_2(\alpha)$:

$$\begin{aligned} I_1 \equiv \rho r_2(0) - r_2(\alpha) + (1-\rho) r_2(\xi_0) &= \rho \frac{\theta}{1-\theta} - \frac{\theta(1-\alpha)}{\theta\alpha - \theta + 1} + (1-\rho)\frac{\theta(1-\xi_0)}{\theta\xi_0 - \theta + 1} \\ &= \theta\left[\frac{\rho}{1-\theta} - \frac{1-\alpha}{\theta\alpha-\theta+1} + (1-\rho)\frac{1-\xi_0}{\theta\xi_0-\theta+1}\right]. \end{aligned} \tag{30}$$

Also I_1 can be written as

$$I_1 = \rho r_2(0) - r_2(\alpha) + (1-\rho) r_2(\xi_0) = \rho(r_2(0) - r_2(\xi_0)) + r_2(\xi_0) - r_2(\alpha). \tag{31}$$

To study the sign of $\frac{\partial I_1}{\partial \rho}$ we differentiate (31):

$$\frac{\partial I_1}{\partial \rho} = r_2(0) - r_2(\xi_0) + (1-\rho)\frac{dr_2(\xi_0)}{d\rho}.$$

Since $r_2(0) - r_2(\xi_0) > 0$ and from (28) we have $\frac{dr_2(\xi_0)}{d\rho} < 0$, then the sign of $\frac{\partial I_1}{\partial \rho}$ is ambiguous. However, if $\rho \to 1$, then $\frac{\partial I_1}{\partial \rho} > 0$.

To study the sign of $\frac{\partial I_1}{\partial \theta}$ we differentiate (31):

$$\frac{\partial I_1}{\partial \theta} = \rho\frac{\partial r_2(0)}{\partial \theta} - \frac{\partial r_2(\alpha)}{\partial \theta} + (1-\rho)\frac{\partial r_2(\xi_0)}{\partial \theta}.$$

This can be positive or negative depending on the value of parameters. Because (25) is satisfied, if $\rho \to 0$ then $\frac{\partial I_1}{\partial \theta} > 0$, and if $\rho \to 1$ then $\frac{\partial I_1}{\partial \theta} < 0$. Also, using (30), if $\theta \to 1$ then , $I_1 \to +\infty$ and if $\theta \to 0$ then $I_1 \to 0$.

Finally, using (27), we obtain $\frac{\partial I_1}{\partial \alpha} < 0$.

We also study the intercept of (10), $r_2(0) - r_2(\alpha)$,

$$I_2 \equiv r_2(0) - r_2(\alpha). \tag{32}$$

It easy to show

$$\frac{\partial I_2}{\partial \rho} = 0 \tag{33}$$

$$\frac{\partial I_2}{\partial \alpha} = 0. \tag{34}$$

Also,

$$\frac{\partial I_2}{\partial \theta} = \frac{\partial r_2(0)}{\partial \theta} - \frac{\partial r_2(\alpha)}{\partial \theta}.$$

Because (25) is satisfied, then we have

$$\frac{\partial I_2}{\partial \theta} > 0. \tag{35}$$

Using the derivatives of I_1 and I_2, and the graph with the equilibrium (see Figure 6), we show the following:

If $\rho \to 1$, then $r_t = r_d + r_2(0) - r_2(\alpha)$, and the equilibrium region of r_t is shifted up (i.e, r_t increases).

If θ increases, the equilibrium region of r_t does not have a clear behavior (I_2 increases, but I_1 does not have a clear pattern). However, if $\theta \to 1$ then $r_d \to +\infty$.

If α increases, the equilibrium region of r_d is shifted down (i.e, r_t decreases)

C Empirical model

C.1 Definition of variables

Next, we define the bank-level variables that we use (which are similar to the variables used in Duchin and Sosyura (2014)):

Camels proxies:

- Capital adequacy: Tier-1 risk-based capital ratio,measured by the ratio of Tier-1 capital to risk-weighted assets.
- Asset quality: Negative of noncurrent loans and leases scaled by total loans and leases.
- Management quality: Negative of the number of corrective actions that were taken against bank executives by the corresponding banking regulator (Fed,OTS,FDIC,and OCC) each year.
- Earnings: return on equity (ROE), measured by the ratio of quarterly net income to total equity capital.
- Liquidity: cash divided by deposits.
- Sensitivity to market risk: sensitivity to interest rate risk, measured by the ratio of the absolute difference between short-term assets and short-term liabilities to earning assets.

Bank fundamentals:

- Size: natural logarithm of book assets.
- Age: age in years since they year an institution was established.
- Exposure to regional economic shocks: weighted average of quarterly changes in the state-coincident macro indicator ("State Coincident Index") from the Federal Reserve Bank of Philadelphia across all states in which a given bank maintains active branches. This index combines four state-level indicators (nonfarm payroll employment, average hours worked in manufacturing, the unemployment rate, and wages and salaries deflated by a price index) to summarize current economic conditions in a single statistic. The weights represent the fraction of the bank's deposits held in the branches in a given state.
- Foreclosures: backward-looking measure of loan quality and exposure to the crisis, measured as the value of foreclosed assets divided by net loans and leases.
- Loan charge-offs: ratio of net loan charge-offs to total loans.
- Funding mix: ratio of deposit funding from purchased money to core deposits.

Investment portfolios:

- Lower-risk securities: U.S. Treasury securities and securities issued by states and political subdivisions.

- Riskier securities: mortgage-backed securities(excluding government-sponsored agency obligations), other domestic and foreign debt securities, and investments in mutual funds and equity products.
- Long-term debt securities: debt securities with the remaining maturity greater than five years.

Bank risk:

- ROA volatility: standard deviation of quarterly ROA over the trailing year.
- Z-score: ROA plus capital asset ratio divided by the standard deviation of ROA.

Liquidity access variables:

- DW: Dummy variable equal to 1 if the bank obtained at least 95% of their Fed funds from DW (as percentage of total funds from TAF+DW) before Lehman Brothers failure.
- TAF: Dummy variable equal to 1 if the bank obtained at least 95% of their Fed funds from TAF (as percentage of total funds from TAF+DW) before Lehman Brothers failure.
- TARP: Dummy variable equal to 1 if the bank accessed the TARP program.

Funding:

- Interest expenses are categorized as
  - Interest expense on domestic deposits (total)
  - Interest expense on domestic deposits (transaction accounts)
  - Interest expense on domestic deposits (savings accounts)
  - Interest expense on domestic deposits (time deposits of less than 100,000 USD)
  - Interest expense on domestic deposits (time deposits of more than 100,000 USD)
  - Interest expense on foreign deposits
  - Interest expense on Fed Funds purchased (interbank borrowing)
  - Subordinated notes and debenture: Interest expense on subordinated notes and debentures.
  - Demand notes and other borrowed money: Interest expense on demand notes issued to the U.S. Treasury, other borrowed money and interest on mortgage indebtedness and obligations under capitalized leases on a consolidated basis.
- Wholesale funding:
  - % wholesale funds: Ratio of total liabilities (excluding insured deposits) to total liabilities.
  - % wholesale funds (narrow): Ratio of (total liabilities excluding insured deposits, subordinated debt, and other borrowed money) to total liabilities. "other borrowed money" excludes deposits, federal funds purchased, securities sold under agreements to repurchase in domestic offices of the bank, and trading liabilities)

Table C.1: Summary Statistics for mainly TAF, mainly DW and all other banks

We show key statistics for TAF mainly, DW mainly and all other banks. We also show statistics for the pre-Lehman period and the post-Lehman period.

	Pre-Lehman (2007)						Test		
	DW banks		TAF banks		Other banks		DW>TAF	DW>Other	TAF>Other
	mean	se	mean	se	mean	se	p-value	p-value	p-value
Assets (billions)	7.70	1.72	60.06	13.57	1.45	0.14	0.00	1.00	1.00
Asset quality (%)	-0.001	0.000	-0.000	0.000	-0.027	0.011	0.03	0.69	0.57
Return on assets (%)	0.99	0.04	1.27	0.06	0.89	0.02	0.01	0.86	0.91
Return on equity (%)	10.24	0.27	11.80	0.47	8.72	0.07	0.03	1.00	1.00
Tier 1 capital ratio (%)	13.76	0.40	16.58	1.85	21.73	0.59	0.02	0.00	0.26
Leverage ratio	11.21	0.07	12.36	0.23	10.06	0.02	0.00	1.00	1.00
Sensitivity to market risk (%)	23.17	0.44	23.65	1.44	23.78	0.10	0.36	0.09	0.46
Foreclosures (%)	0.05	0.01	0.07	0.01	0.05	0.00	0.09	0.42	0.87
Loan chargeoffs (%)	0.20	0.01	0.64	0.17	0.20	0.01	0.00	0.44	1.00
Funding mix (%)	1.35	0.03	1.08	0.03	1.64	0.09	1.00	0.25	0.32
Low risk securities (%)	3.50	0.11	1.31	0.13	4.02	0.03	1.00	0.00	0.00
High risk securities (%)	1.03	0.11	1.41	0.41	0.52	0.01	0.13	1.00	1.00
Long-term securities (%)	6.28	0.21	4.68	0.39	6.46	0.04	1.00	0.19	0.00
Std. deviation of ROA	0.25	0.02	0.15	0.01	0.29	0.00	0.96	0.03	0.02
z-score	225.07	13.69	252.57	33.08	238.22	3.37	0.25	0.20	0.62
Liquidity ratio (%)	4.87	0.33	4.56	0.37	55.19	12.34	0.63	0.19	0.38
Macro growth index (%)	1.47	0.03	1.17	0.11	1.62	0.01	1.00	0.00	0.00
Enforcement last 2 years (%)	0.18	0.01	0.36	0.04	0.09	1.00	0.00	1.00	1.00
Bank age (years) (%)	60.19	1.16	74.28	3.84	67.23	0.24	0.00	0.00	0.99
Observations	1,524		188		34,385				

Table C.2: Differences between treated and matched samples (funding cost regressions).

Test of differences between covariates of treated samples (DW and TAF) and matched samples. Matching is done using covariates used in funding cost FE regressions. We report mean values for the entire sample, the DW banks, the TAF banks, the matched banks and the p-values of the test of differences.

		DW matching				TAF matching			
	All	DW	others	Difference	p-value	TAF	others	Difference	p-value
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Asset (log)	-1.930	-0.456	-0.443	-0.013	0.762	2.019	2.135	-0.116	0.452
ROA	8.479	10.195	10.852	-0.656	0.530	11.797	12.848	-1.051	0.432
ROE	8.479	10.195	10.852	-0.656	0.530	11.797	12.848	-1.051	0.432
Liquidity ratio	58.037	4.760	4.406	0.354	0.501	4.505	3.254	1.251	0.096
Asset quality	-0.000	-0.000	-0.000	-0.000	0.638	-0.000	-0.000	-0.000	0.347
Sensitivity to market risk	24.073	23.172	24.284	-1.113	0.370	24.167	22.286	1.881	0.645
Foreclosures	0.049	0.048	0.055	-0.007	0.692	0.068	0.030	0.038	0.018
Loan chargeoffs	0.200	0.194	0.209	-0.015	0.732	0.634	0.184	0.450	0.098
Funding mix	1.636	1.354	1.302	0.052	0.479	1.098	0.964	0.135	0.180
Low risk securities	4.007	3.498	3.376	0.122	0.719	1.343	1.949	-0.606	0.283
High risk securities	0.517	1.008	0.836	0.171	0.509	0.624	0.673	-0.050	0.868
Long-term securities	6.435	6.067	6.063	0.004	0.994	4.779	3.982	0.797	0.386
Std. deviation of ROA	0.304	0.246	0.248	-0.002	0.970	0.150	0.119	0.031	0.195
z-score	236.600	225.217	214.412	10.805	0.629	252.573	319.907	-67.334	0.461
Bank age	66.605	60.234	59.563	0.671	0.842	74.022	64.674	9.348	0.426
Enforcement last 2 years	0.090	0.182	0.218	-0.037	0.166	0.370	0.261	0.109	0.280
Macro growth index	1.622	1.469	1.510	-0.042	0.651	1.142	1.488	-0.346	0.254

Table C.3: Fixed effects regression of matched samples for funding cost for years 2010 and 2007 (total and by type of funding source).

This table shows results of fixed effects regression of funding cost by type of funding source for matched samples. We show results total interest expense ("eintexp", as a % of total liabilities) in (1); interest expense for domestic deposits (as fraction of value of domestic deposits) in (2); interest expense for transaction accounts (as fraction of value of transaction accounts) in (3); interest expense for saving accounts (as fraction of value of saving accounts) in (4); interest expense for time deposits of less than 100,000 USD (as fraction of value of time deposits of less than 100,000 USD) in (5); interest expense for time deposits of more than 100,000 USD (as fraction of value of time deposits of more than 100,000 USD) in (6); interest expense for foreign deposits (as fraction of value of foreign deposits) in (7); interest expense for interbank borrowing (as fraction of value of interbank borrowing) in (8); interest expense for subordinated debt (as fraction of value of subordinated debt) in (9); and interest expense for other borrowing (as fraction of value of other borrowing) in (10). All regressions use quarterly data for banks in 2010 (post-Lehman period) and 2007 (pre-Lehman period). DW= Dummy equal to 1 if bank was DW mainly in the pre-Lehman period. TAF= Dummy equal to 1 if bank was TAF mainly in the pre-Lehman period. Post= Dummy equal to one for the post-Lehman period (2010), and equal to zero for 2007. TARP= Dummy equal to 1 if bank was part of the TARP program.

	Total	Domestic deposits					Foreign	Interbank	Subordin.	Other
	funding	All	Transaction	Saving	Time depos.	Time depos.	deposits	borrowing	debt	borrowing
	cost	deposits	accounts	accounts	(<100)	(>100)				
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$DW_{pre} \times Post$	-0.0207***	-0.0130	-0.0110	-0.0179	0.0229	-0.0691***	0.00972	0.00241	0.0740	-0.0505*
	(0.00801)	(0.00804)	(0.0143)	(0.0142)	(0.0158)	(0.0223)	(0.0925)	(0.0376)	(0.164)	(0.0286)
$TAF_{pre} \times Post$	-0.0637***	-4.03e-05	0.0307	-0.0135	0.0100	-0.0595	0.0279	-0.148	-0.0372	-0.0883
	(0.0241)	(0.0328)	(0.0427)	(0.0416)	(0.0447)	(0.0673)	(0.134)	(0.112)	(0.230)	(0.0978)
Bank level controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarterly fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	20,621	20,621	18,471	18,498	18,440	18,458	605	9,522	1,496	15,666
Number of banks	2,804	2,804	2,521	2,516	2,513	2,520	93	1,775	278	2,433
R squared	0.889	0.888	0.148	0.736	0.806	0.762	0.784	0.431	0.329	0.129
H_1 : Funding cost for DW banks in post Lehman period ($DW_{pre} \times Post$) $\leq$ Funding cost for TAF banks in post Lehman period ($TAF_{pre} \times Post$)										
15% significance	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT
10% significance	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT
5% significance	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.4: Endgenous treatment effects (first stage): Access to DW and TAF.

This table shows results of the first stage of the endogenous treatment regressions for banks that mainly used the DW and banks that mainly used the TAF. 'Member of the board of the Fed' is an indicator variable equal to one if the bank was part of the board of the Federal Reserve System in the last 3 years.

Regressors	DW access (1)	TAF access (2)
Member of the board of the Fed	-0.179***	-0.222**
	(0.049)	(0.091)
TARP	0.196***	0.164*
	(0.038)	(0.089)
Asset (log)	0.279***	0.415***
	(0.007)	(0.016)
ROA	-0.016**	-0.018
	(0.008)	(0.038)
ROE	-0.000	0.000
	(0.001)	(0.003)
Liquidity ratio	-0.001	-0.001
	(0.001)	(0.002)
Asset quality	0.118	0.188
	(0.342)	(0.975)
Sensitivity to market risk	0.002**	0.007***
	(0.001)	(0.002)
Foreclosures	0.025*	-0.148
	(0.013)	(0.214)
Loan chargeoffs	-0.013	0.074***
	(0.008)	(0.018)
Funding mix	-0.002	-0.093*
	(0.001)	(0.052)
Low risk securities	0.006***	-0.039***
	(0.002)	(0.011)
High risk securities	0.023***	-0.044**
	(0.003)	(0.018)
Long-term securities	-0.004***	-0.002
	(0.001)	(0.005)
Std. deviation of ROA	0.016	-0.283***
	(0.012)	(0.074)
Z-score	-0.000	0.000
	(0.000)	(0.000)
Bank age	-0.001***	-0.000
	(0.000)	(0.001)
Enforcement last 2 years	0.125***	-0.131*
	(0.025)	(0.068)
Macro growth index	0.002	-0.071***
	(0.007)	(0.020)
Quarterly fixed effects	YES	YES
Observations	64,627	64,627
Pseudo R squared	0.115	0.384

Robust standard errors in parentheses
*** p<0.01, **p<0.05, *p<0.1

Table C.5: Endgenous treatment effects (second stage) for funding cost for years 2010 and 2007 (total and by type of funding source).

This table shows results of fixed effects regressions of funding cost by type of funding source. We show results total interest expense (as a % of total liabilities) in (1); interest expense for domestic deposits (as % of domestic deposits) in (2); interest expense for transaction accounts (as % of transaction accounts) in (3); interest expense for saving accounts (as % of saving accounts) in (4); interest expense for time deposits of less than 100,000 USD (as %) in (5); interest expense for time deposits of more than 100,000 USD (as %) in (6); interest expense for foreign deposits (as %) in (7); interest expense for interbank borrowing (as % of interbank borrowing) in (8); interest expense for subordinated debt (as % of subordinated debt) in (9); and interest expense for other borrowing (as % of other borrowing) in (10). All regressions use quarterly data for banks in 2010 (post-Lehman period) and 2007 (pre-Lehman period). DW= Dummy equal to 1 if bank was DW mainly in the pre-Lehman period. TAF= Dummy equal to 1 if bank was TAF mainly in the pre-Lehman period. Post= Dummy equal to one for the post-Lehman period (2010), and equal to zero for 2007. TARP= Dummy equal to 1 if bank was part of the TARP program.

	Total	Domestic deposits					Foreign	Interbank	Subordin.	Other
	funding	All	Transaction	Saving	Time depos.	Time depos.	deposits	borrowing	debt	borrowing
	cost	deposits	accounts	accounts	(<100)	(>100)				
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$DW_{pre} \times Post$	-0.034***	-0.028***	-0.017	-0.034**	0.015	-0.087***	-0.184**	-0.030	-0.009	-0.048*
	(0.008)	(0.008)	(0.014)	(0.014)	(0.015)	(0.022)	(0.071)	(0.035)	(0.160)	(0.028
$TAF_{pre} \times Post$	-0.100***	-0.077***	0.023	-0.041**	-0.036	-0.100***	-0.228**	-0.184	0.065	-0.151*
	(0.021)	(0.032)	(0.046)	(0.046)	(0.046)	(0.079)	(0.121)	(0.102)	(0.238)	(0.107
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarterly fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	64,490	64,483	57,903	57,955	57,936	57,898	672	21,945	1,906	41,862
Number of banks	8,763	8,762	7,912	7,899	7,902	7,917	103	4,718	362	6,698
R squared	0.891	0.890	0.172	0.704	0.829	0.776	0.790	0.381	0.260	0.119
H_1 : Funding cost for DW banks in post Lehman period ($DW_{pre} \times Post$) $\leq$ Funding cost for TAF banks in post Lehman period ($TAF_{pre} \times Post$)										
15% significance	REJECT	REJECT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT
10% significance	REJECT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT	ACCEPT
5% significance	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT

Robust standard errors in parentheses
*** p<0.01, **p<0.05, *p<0.1