Discount Window Stigma during the 2007-2008 Financial Crisis

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Abstract

We provide empirical evidence for the existence, magnitude, and economic cost of stigma associated with banks borrowing from the Federal Reserve's Discount Window (DW) during the 2007-08 financial crisis. We find that banks were willing to pay a premium of around 44 basis points across funding sources (126 basis points after the bankruptcy of Lehman Brothers) to avoid borrowing from the DW. DW stigma is economically relevant as it increased some banks' borrowing cost by 32 basis points of their pre-tax return on assets (ROA) during the crisis. The implications of our results for the provision of liquidity by central banks are discussed.

Key words: Discount Window, Term Auction Facility, stigma, crisis, monetary policy

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In August 2007,...banks were reluctant to rely on discount window credit to address their funding needs. The banks' concern was that their recourse to the discount window, if it became known, might lead market participants to infer weakness—the so-called stigma problem. - Bernanke (2009)

1. Introduction

A core function of central banks is to act as a "lender of last resort" to the banking system. In the US, the Federal Reserve (the Fed) uses the Discount Window (DW) to fulfill this task. Historically, however, the DW has been little used, even when banks faced acute liquidity shortages. For example, despite several measures enacted by the Fed to encourage DW borrowing (see Section 2.1), banks scarcely accessed the DW at the onset of the 2007 financial crisis. Although other explanations may exist, this lack of DW borrowing is commonly attributed to stigma (see Chairman Bernanke's quote above). In this paper, we take advantage of a unique episode to provide empirical evidence for the existence, magnitude, and economic cost of DW stigma during the financial crisis of 2007–2008.

DW stigma is defined as a reluctance to access the DW out of concerns that, if detected, depositors, creditors, or analysts could interpret DW borrowing as a sign of financial weakness.[1] As argued by Madigan (2009) and Duke (2010), the economic consequences of DW stigma may be most severe during financial crises when market participants have strong incentives to identify the weakest financial firms. First, a bank may delay access to the DW resorting instead to costly alternatives (e.g., fire-sales of assets) which may further weaken the bank and increase financial instability. Second, it could lead banks to excessive self-

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[1]DW stigma may exist with respect to market participants or with respect to the Fed if banks are concerned that borrowing from the DW sends a negative signal to the Fed which acts both as lender and a regulator (Furfine, 2003). In this paper, we focus on DW stigma with respect to the market.

insurance against tail-risks thereby reducing the loans extended to the real economy. Third, if banks are especially reluctant to access the DW during financial crises, then DW stigma may prevent central banks from effectively providing emergency liquidity. In particular, Winters (2012) argues that stigma limited the effectiveness of the Bank of England (BoE) DW during the recent financial crisis and resulted in substantial costs to the financial system.

According to standard economic theory, DW stigma can emerge in equilibrium if, given asymmetric information, market participants infer banks' financial conditions based on observed DW borrowings (Philippon and Skreta, 2012; Ennis and Weinberg, 2013). Therefore, a necessary condition for DW stigma to exist is that banks must believe there is a chance their identities will be made public soon after they borrow from the DW. Although central banks do not disclose the borrowers' identity in real time, the information appears to have been leaked by the media on occasions.[2] Beyond media coverage, two identification channels are often mentioned. First, DW borrowers may be identified from the Fed's weekly public report of aggregate DW borrowings by district, especially for banks outside the New York district [as argued by, for example, Duke (2010) and Berry (2012)]. Second, analysts, bankers, and investors may be able to make educated guesses about possible DW borrowers based on market activity.[3] Because the identities of DW borrowers have been made public in the past, a bank should reasonably believe that its access to the DW might be inferred. Hence, it appears that the sufficient condition for the existence of DW stigma is satisfied.

Actual empirical evidence of DW stigma, however, is scarce to nonexistent. One way to identify DW stigma is through one of its manifestations: to avoid DW stigma, banks should

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[2]For instance, the financial press reported on August 20, 2007 that Deutsche Bank had accessed the DW on the previous business day (see "Fed fails to calm money markets," *The Financial Times*, August 20, 2007). Similarly, Barclays' use of the BoE DW in August 2007 was immediately reported in the press (see "Barclays admits borrowing hundreds of millions at Bank's emergency rate," *The Guardian*, August 30, 2007). Finally, a recent BoE report concludes that a BBC leak that Northern Rock had received funds from the BoE was instrumental in the bank's demise (see Treasury, 2008).

[3]See "Banks face borrowing stigma," *The Wall Street Journal*, April 1, 2011 or "Bernanke responds to pressure for transparency as Fed discloses borrowers," *Bloomberg*, March 31, 2011.

be willing to pay higher rates for loans with terms similar to those at the DW. In normal times, it is difficult to observe such overpayments since market alternatives are generally available at lower rates.[4] Alternatively, the absence of DW borrowing in times of crises may not be sufficient to prove that DW stigma exists as there may be other explanations. For instance, Armantier, Krieger, and McAndrews (2008) argue that the scarcity of DW borrowing in the fall of 2007 was due to the availability of less expensive market alternatives.

To test whether DW stigma exists, we take advantage of a unique historical event: In December 2007, the Fed introduced a temporary liquidity program, the Term Auction Facility (TAF), specifically designed to eliminate concerns of stigma attached to the DW. As a result, and in contrast to the DW, the TAF was an immediate success in terms of amounts borrowed (see Fig. 1). While a bank could borrow both at the DW and at the TAF, we use a simple arbitrage argument to show that, absent DW stigma, a TAF bidder should never have bid above the prevailing DW rate. We find strong evidence supporting the existence of DW stigma during the 2007–2008 financial crisis. In particular, more than half of the TAF participants submitted bids above the DW rate during our sample period (December 17, 2007 to September 22, 2008). Moreover, about half of the banks bidding above the DW rate did so in at least two-thirds of the auctions at which they participated, indicating that their bidding behavior was not the result of idiosyncratic errors.

We next examine the magnitude of DW stigma during the crisis. To do so, we calculate the premia banks were willing to pay to avoid borrowing at the DW. We consider three alternatives to the DW: the TAF, as well as two short-term funding markets which were reasonably close substitutes to borrowing at the DW—the tri-party repo ("repo"from now

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[4]Moreover, it is difficult to find adequate market substitutes for DW loans. In particular, prior estimates of DW stigma relied on comparisons with Fed funds market rates (e.g., Furfine, 2001, 2003) which do not constitute an "apples-to-apples"comparison since the borrowing terms are different from those at the DW (e.g., Fed funds loans are not collaterized, in contrast to DW loans). In addition, these papers rely on Fed funds transactions that are not observed directly. Instead, they must be inferred using an algorithm which has recently been shown to produce large (in excess of 80%) type I errors (Armantier and Copeland, 2014).

on) and Asset-Backed Commercial Paper (ABCP) markets. We find the DW stigma premium relative to the TAF, ABCP, and repo rates to be of similar magnitude during our sample period, amounting to an average of 44, 42, and 46 bps, respectively. Banks' opportunity costs of avoiding the DW were substantial. For example, banks that obtained TAF funding during our sample period incurred an additional interest cost of $172 million per auction, resulting in a 7.5% increase in their interest payments and a decrease of 17 bps in their pre-tax return on assets (ROA). Immediately after the bankruptcy of Lehman Brothers, at the apex of the financial crisis, the magnitude of DW stigma rose considerably to at least 143 bps with respect to TAF, implying an additional interest cost of $1.13 billion per auction, equivalent to 40% of TAF interest payments.

Finally, we use regression analysis to explore the possible determinants of DW stigma. Consistent with Duke (2010) who argued that DW visits by banks in smaller Federal Reserve districts are easier to detect, we find that banks outside New York have a higher incidence of DW stigma. Moreover, our results reveal that all else equal, and in particular after controlling for a bank's reliance on retail funding, foreign banks are more likely to experience DW stigma. We find some evidence that a bank is more concerned about DW stigma when financial markets become stressed and when it is perceived to be in poor financial condition by market participants. We also find lower DW stigma for banks that recently borrowed from the DW. Finally, there is no evidence for a herding effect whereby a bank's DW stigma declined after more banks, and in particular, more banks in its peer group (as defined by asset size and federal district), had accessed the DW.

We believe this paper contributes to the literature by providing empirical evidence for the existence of stigma in financial markets, and estimates for the magnitude and cost of DW stigma during the 2007–2008 financial crisis. As further discussed in the conclusion, these results have implications for the implementation of monetary policy in normal times,

as well as the effective management of lending facilities in times of financial crises.

2. Institutional background

An important role of central banks is to provide funding to illiquid but solvent banks during times of either aggregate or idiosyncratic liquidity shocks in the banking system (Freixas et al., 1999). In this section, we provide a brief historical perspective on DW and TAF operations emphasizing the issue of stigma.

2.1. The Discount Window

In normal times, solvent but illiquid banks should be able to obtain funding from banks with excess liquidity via the interbank market—see, notably, Selgin (1993). However, the interbank market may become dysfunctional, due to asymmetric information problems for instance, so that even solvent banks are unable to obtain credit. In such a case, central banks may be in a better position to supply liquidity in a targeted manner to illiquid institutions.[5] In the US, the traditional way for the Fed to provide emergency credit to depository institutions is through the DW. Lending from the DW is in the form of "advances," which are loans evidenced by promissory notes of the borrowing bank and secured by adequate collateral. All depository institutions that maintain reservable transaction accounts or non-personal time deposits are entitled to borrow at the DW. These include any Federal Deposit Insurance Company (FDIC)-insured bank, savings or mutual bank, insured credit union, and US branch and agency of a foreign bank.[6]

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[5]Flannery (1996), Freixas et al. (1999), Berger, Davies, and Flannery (2000), and Rochet and Vives (2004) discuss reasons why central banks may be better providers of liquidity than the interbank market. For an opposite view on the issue, see Goodfriend and King (1988).

[6]For exact DW eligibility criteria, see http://www.frbdiscountwindow.org/discountwindowbook_pf.pdf.

The question of stigma has been a lingering issue throughout the history of the DW and led to fundamental reforms in 2003. Prior to 2003, banks in distress could borrow from the DW at a rate below the Fed target rate. Because of the subsidized rate, the Fed was concerned about "opportunistic overborrowing" by banks. Accordingly, before accessing the DW, a bank had to satisfy the Fed that it had exhausted private sources of funding and that it had a genuine business need for the funds. Hence, if market participants learned that a bank had accessed the DW, then they could conclude that the bank had limited sources of funding. The *old* DW regime therefore created a perception of stigma since DW borrowers revealed financial weakness to the Fed and possibly to competitors. These concerns may have deterred banks from accessing the DW even if they had an urgent need for funds.

To address concerns about DW stigma, the Fed fundamentally changed its DW policy on January 9, 2003. In Regulation A, the Fed classified DW loans into primary credit, secondary credit, and seasonal credit. Financially strong and well-capitalized banks can borrow under the primary credit program at a penalty rate above the target Fed funds rate (rather than a subsidized rate as in the past). Other banks use the secondary credit program and pay a rate higher than the primary credit rate. Finally, seasonal credit is for relatively small banks with seasonal fluctuations in reserves. By far, the most common form of DW borrowing (with a 99% share during our sample period) is through the primary credit program. Therefore, our focus in this paper is exclusively on the primary credit facility. Further, whenever we refer to the DW rate, we mean the DW primary credit rate.

The *new* DW is a "no questions asked" facility for primary credit. Namely, the Fed no longer establishes a bank's sources and needs for funding. Instead, primary credit for overnight maturity is allocated with minimal administrative burden. Hence, borrowing from the *new* DW need not be motivated by pressing funding needs or signal financial weakness.

Despite these changes, DW borrowing remained sparse after 2003 and perceptions of

stigma resurfaced at the onset of the recent financial crisis. By the end of the summer of 2007, financial institutions were perceived to face serious liquidity shortages for term funding (Hilton and McAndrews, 2011). To encourage borrowing, the Fed reduced the DW penalty (i.e., the spread over the target rate) from 100 bps to 50 bps on August 17, 2007 and increased the term of DW financing from overnight to as long as 30 days. In addition, the Fed issued statements that DW borrowing would be viewed as a sign of strength and not a sign of weakness (Hilton and McAndrews, 2011). As indicated in Fig. 1, which shows the average weekly DW primary credit outstanding, these changes in policy generated little DW borrowing in the second half of 2007. Stigma was believed to be the main contributing factor to the persistent reluctance in accessing the DW, as illustrated by the quote from Chairman Bernanke at the beginning of the paper.

2.2. The Term Auction Facility

In response to persistently adverse liquidity conditions in the interbank markets, the Fed announced the creation of the TAF on December 12, 2007. The TAF was designed as an alternative to the DW to provide term funding with a primary objective of eliminating any perception of stigma attached to borrowing from the DW. A total of 60 TAF auctions were conducted every two weeks between December 17, 2007 and March 8, 2010 when the TAF program was terminated. The amount of credit allocated by the Fed at each auction varied from $20 billion initially to $150 billion at the peak of the crisis. With a few exceptions, the terms of the funds allocated were 28 days, and after August 11, 2008, 84 days.

Since the TAF was introduced as an alternative to the DW, the two facilities shared a number of important features. As indicated in Table 1, where the two facilities are compared, funding was offered against the same collateral, using identical haircut calculations. In

addition, the same institutions, namely, those deemed in sound financial condition by their Federal Reserve District Bank, had access to both facilities. Finally, at the time, the identities of borrowers were not disclosed at either facility.

The TAF and the DW facilities are also different in some respects. First, the DW offers a posted rate determined by the Fed, while the borrowing rate at the TAF was set competitively at an auction. More precisely, TAF bids were accepted in descending order of rates until the funds supplied at the auction were exhausted. The borrowing rate for all winning bidders was then set to the lowest accepted bid rate (the "stop-out rate").[7] Second, the amount of credit allocated at a TAF was fixed by the Fed before each auction, while the amount of credit available to the banking system at the DW is limited by the amount of collateral posted by banks at the Fed. At the bank level, borrowing at both facilities was limited by the amount of collateral the bank had posted at the Fed, but a bank's TAF borrowing was further limited to 10% of the total amount supplied by the Fed at the auction. Third, whereas DW loans are credited on the same day, TAF awards were only credited three days after the auction. Fourth, while most TAF auctions allocated funds for 28 days during our sample period, DW loans could be obtained for any term up to 30 days after August 17, 2007 and up to 90 days after March 16, 2008. Fifth, the DW facility is available every business day, whereas the TAF was operated at two-week intervals. Finally, TAF loans could not be prepaid, while DW loans can be repaid at any time.

Some features of the TAF facility were purposely introduced by the Fed to remove the concerns of stigma that were attached to the DW. In particular, having banks approach the Fed collectively, rather than individually, and obtaining funds at a competitive rate after a three-day delay, rather than immediately at a premium set by the Fed, were expected to mitigate any perception that TAF participation was primarily motivated by a pressing

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[7]For undersubscribed auctions, the TAF borrowing rate was automatically set to the overnight index swap (OIS) rate until January 12, 2009 and the Fed's rate of interest on excess reserve balances afterward.

need for funding.[8] In addition, a fully subscribed TAF auction would have at least ten winners (given the 10% cap on bid size) which further reduced the likelihood of an individual institution being publicly singled out. In contrast to the DW, the TAF was an immediate success in terms of amounts bid and allocated (see Fig. 1), which provides prima facie evidence that less, if any, stigma was attached to TAF borrowing.

3. Methodology

In the first subsection, we describe our empirical methodology to establish the existence of stigma associated with DW borrowing. We then examine the magnitude of DW stigma with respect to the TAF and with respect to two short-term funding markets. Finally, we propose a method to estimate the opportunity cost of DW stigma.

3.1. Testing for the presence of DW stigma

As explained in the previous section, the terms of a 28-day loan secured at the DW are equal or superior to the terms of a TAF loan. Indeed, a bank that borrowed at the TAF was able to obtain the same amount of credit, on the same date, for the same duration, and against the same collateral at the DW. Where differences existed between the two facilities, the effect was to make a DW loan more attractive. In particular, DW loans could be repaid early which allowed banks to benefit from lower rates if the Fed reduced its target rate during the term of the loan, as could be expected at the time. It therefore follows that, absent DW stigma, banks had no reason to pay higher rates at the TAF than at the DW.

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[8]For further details on how the TAF was designed to remove stigma, see Armantier et al. (2008). For a transcript of the discussions surrounding the creation of the TAF, see http://www.federalreserve.gov/monetarypolicy/files/FOMC20071206confcall.pdf.

We now show that, absent DW stigma, submitting a TAF bid below the DW rate is a dominant strategy. Recall first that the TAF borrowing rate is set by the lowest accepted bid rate. Thus, if a bank receives TAF funds, then it is guaranteed to pay a rate at or below its own bid rate. By bidding below the DW rate a bank either i) receives the TAF funds in which case it pays a rate below the DW rate, or ii) does not get the TAF funds in which case it can turn to the DW on the TAF settlement day (i.e., the day after the auction results are announced) and pay the DW rate. In either case, the bank is able get the funds at a rate that does not exceed the DW rate. In contrast, by bidding above the DW rate, a bank takes the risk of paying more than the DW rate. This happens when the lowest accepted bid rate is above the DW rate and below the bank's own bid rate. This bidding strategy is therefore dominated (absent DW stigma), as the bank is better off bidding below the DW rate, in which case it always obtains the funds at or below the DW rate.

In summary, absent DW stigma, a TAF participant cannot do better by bidding above the DW rate.[9] In contrast, the only reason (other than idiosyncratic errors) a bank may be willing to bid above the DW rate is because it is concerned about DW stigma. This simple arbitrage argument forms the basis of our empirical methodology: absent DW stigma, a bank should never bid above the DW rate and a bid above the DW rate will therefore be interpreted as evidence of DW stigma.

3.2. The magnitude of DW stigma

We define the "DW stigma rate" as the highest interest rate a bank is willing to pay to avoid borrowing at the DW. By extension, we define the "DW stigma premium" as the

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[9]Because it is a dominated strategy, bidding above the DW rate can only occur in equilibrium if a bank believes that the auction will settle below the DW rate with probability one. After October 2008, every TAF auction was undersubscribed and therefore settled at the minimum bid rate. It may therefore be argued that TAF participants did place probability one on the event that the auctions would settle below the DW rate. As further discussed below, this is the reason why our sample only includes fully subscribed auctions.

difference between the DW stigma rate and the DW rate. These variables are only defined when a bank exhibits DW stigma, that is, when the DW stigma premium is positive.

Because a bank's highest willingness to pay cannot be observed, the DW stigma premium is a latent variable. Instead, we calculate the "realized DW stigma premium" by measuring how much more banks were willing to pay at the TAF and in financial markets to avoid borrowing at the DW. These proxies, however, have at least two limitations. First, they only provide lower bounds on the DW stigma premium. Indeed, a bank borrowing at $x\%$ above the DW rate may have been willing to pay even more to avoid the DW. Second, although in general the DW stigma premium and its lower bounds may be expected to respond to the same shocks, they could vary independently of each other on occasions. For example, the realized DW stigma premium could vary across banks or over time while the actual DW stigma premium could remain unchanged. Conversely, the DW stigma premium could vary while the realized DW stigma premium could remain unchanged. Therefore, while we may be able to identify the determinants of the realized DW stigma premium, those same determinants may not necessarily extend to the (unobservable) DW stigma premium.

We define the realized DW stigma premium with respect to TAF as the difference between a bank's bid rate at a TAF auction and the DW rate, conditional on the bank bidding above the DW rate.[10] Likewise, we define the realized DW stigma premium with respect to the financial markets as the difference between the relevant market rate and the DW rate, conditional on a positive difference.

As explained in Section 2.2, the terms of a DW loan are either identical to the terms

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[10]An alternative approach to estimating a lower bound on the DW stigma premium with respect to TAF would consist of applying a structural auction model to the data to recover a bank's demand function. A well-known drawback of structural auction models is that they require strong underlying assumptions about, in particular, bidders' information sets, heterogeneity, beliefs, preferences, and whether the private or common value paradigm applies (Athey and Haile, 2006, Reiss and Wolak, 2007). In contrast, our comparison of DW and TAF bid rates is essentially nonparametric.

of a TAF loan (e.g., with respect to eligibility and collateral accepted) or slightly better (e.g., with respect to early repayment). Further, it is easy to show that, in the presence of DW stigma, a bank should not bid at the TAF above its true cost of borrowing at the DW (i.e., the DW stigma rate).[11] Although the TAF seems to have been designed effectively to remove stigma concerns (as suggested by its popularity), we cannot exclude the possibility that some stigma was also attached to TAF borrowing. If this is the case, then the realized DW stigma premium with respect to TAF would be biased downward. Thus, even if the TAF was stigmatized, the realized DW stigma premium with respect to TAF constitutes a valid lower bound for the DW stigma premium.

As an alternative to the TAF, we also measure the realized DW stigma premium with respect to financial markets. However, while the TAF and the DW have similar lending terms, it is more difficult to identify financial markets that offer funding with terms comparable to the DW. Although perfect substitutes do not exist, two markets, the ABCP and repo markets, offered reasonable substitutes to DW loans with respect to eligibility, collateral, and maturity. Identical to the DW, the loans on the ABCP and repo markets are provided against collateral. Further, the collateral used in the repo market is also pledgeable at the DW. Likewise, ABCP issuances appeared to have been secured by similar (albeit somewhat riskier) collateral pools as DW loans during our sample period.[12] Regarding eligibility, large commercial banks who are typical issuers of ABCP have direct access to the DW.[13] Dealers

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[11]The argument is the same as the one we used to show that, in the absence of DW stigma, a bank should not bid above the DW rate.

[12]We provide evidence that similar collateral was used for ABCP and DW loans in the online appendix available here: https://sites.google.com/site/olivierarmantier/. We have little information about how haircuts differed for DW, ABCP, and repo loans. In contrast to the DW, the ABCP and repo haircuts may vary by counterparty. To the extent that ABCP and repo lenders require additional haircuts for riskier collateral or counterparty, they have less incentive to increase rates to adjust for risk. This would make DW and market rates more comparable (since market rates would be less likely to contain a large risk premium).

[13]Large commercial banks fund pools of long-term assets by issuing short-term ABCP through special purpose vehicles or conduits. Although conduit assets are off banks' balance sheets, banks effectively kept the risk exposure on their balance sheets by issuing credit and liquidity guarantees to the conduits (Acharya, Schnabl, and Suarez, 2013). All else equal, the administrative costs of setting up conduits likely makes

in the repo market can access the DW indirectly through their banking affiliates.[14] Finally, during our sample period, the DW offered loans of similar tenor as the ABCP and repo markets. Indeed, ABCP loans are for one- and three-months, while the repo market offers overnight loans. As a final justification for considering the repo and ABCP markets, we note that despite the crisis, these markets remained sufficiently active to produce meaningful price and volume data during our sample period (see the online appendix).

3.3. The Economic cost of DW stigma

The economic relevance of DW stigma may be gauged by evaluating the banks' opportunity cost of avoiding the DW, that is, the interest payments they could have saved by going to the DW. We propose measures of the economic cost of DW stigma when banks borrowed from the TAF, the ABCP market, or the repo market instead of borrowing from the DW.

To evaluate how much it costs for banks to borrow at the TAF instead of at the DW, we first conduct a counterfactual exercise in which we assume that each bank that bids above the DW rate is the marginal bidder that sets the auction stop-out rate. As a result, the bank systematically receives the funds it bids for and pays its own bid. We define the potential cost of DW stigma with respect to TAF for bank i on auction date t as follows:

$$\text{Potential cost-TAF}_{it} = \text{BidAmt}_{it} * (\text{Bid}_{it} - \text{DW}_t) * I_{\text{Bid}_{it} > \text{DW}_t} \,, \tag{1}$$

where DW_t is the DW rate, Bid_{it} and BidAmt_{it} are the bank's TAF bid rate and bid amount, and $I_{x>0}$ denotes the indicator function equal to one when $x > 0$ and zero otherwise. As

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ABCP funding more expensive than DW borrowing (we thank the referee for pointing this out).

[14]The repo market features dealer subsidiaries of bank holding companies that fund their portfolios of securities through repurchase agreements (Copeland, Martin, and Walker, 2011). These dealer subsidiaries are not eligible to access the DW, but the banking subsidiary can borrow from the DW and transfer funds internally to its dealer affiliate subject to regulatory limits, as discussed in Appendix Appendix A.1.

defined, Potential cost-TAF$_{it}$ represents how much more bank i risked paying in interest by bidding at the TAF instead of taking the loan at the DW.

We also measure the realized cost of DW stigma with respect to TAF, that is, the interest payments banks would have saved by funding their actual TAF awards through a loan at the DW. Considering exclusively the TAF auctions that settled above the DW rate, we calculate:

$$\text{Realized cost-TAF}_{it} = \text{AwardAmt}_{it} * (\text{SO}_t - \text{DW}_t) * I_{\text{SO}_t > \text{DW}_t} \ , \tag{2}$$

where SO$_t$ is the TAF stop-out rate, and AwardAmt$_{it}$ is the amount of TAF funds awarded to bank i. Realized cost-TAF$_{it}$ represents how much more bank i actually paid in interest by borrowing at the TAF instead of at the DW.

To evaluate the opportunity cost of DW stigma relative to the repo market, we consider bank holding companies (BHCs) with both a dealer and a commercial banking subsidiary. Then, we estimate the reduction in interest payments if, for each collateral eligible at the DW, the BHC substitutes repo borrowing by its dealer, with DW borrowing by its commercial banking affiliate (Appendix Appendix A.1 explains how this can be done). As noted earlier, our repo data are time-stamped on a monthly basis until September 2008. For bank i, month m, and collateral c eligible at the DW, the opportunity cost of repo funding is:

$$\text{Cost-repo}_{cim} = \text{RepoAmt}_{cim} * (\text{repo}_{cim} - \text{DW}_m) * I_{\text{repo}_{cim} > \text{DW}_m} \ , \tag{3}$$

where repo$_{cim}$ is the bank's monthly average overnight repo rate, DW$_m$ is the monthly average DW rate, and RepoAmt$_{cim}$ is the total amount of repo funding (up to legal limits on fund transfers between BHC affiliates). For the September 2008 data, when repo transactions are time-stamped for the day of occurrence, we calculate (3) at the daily level. When reporting results, we aggregate the repo-based DW stigma costs over all collateral for a bank.

To evaluate the opportunity cost of DW stigma relative to the ABCP market, we estimate the interest savings if bank i had replaced its ABCP outstanding by an equal amount of DW borrowing. Since we do not observe ABCP outstanding, we use a proxy, ABCPcommit_{iq}, defined for bank i and quarter q as:

$$\text{ABCPcommit}_{iq} = \text{Liqcommit}_{iq} * (1/1.02) \,, \tag{4}$$

where Liqcommit_{iq} is the amount of backup liquidity provided by the bank in case its conduit is unable to roll over ABCP debt. Because Liqcommit_{iq} is typically equal to the face amount of ABCP outstanding and because 2% of the backup liquidity is generally set aside to cover the interest component (Bate, Bushweller, and Rutan, 2003), the adjusted value of Liqcommit_{iq} in (4) provides an estimate of the principal amount of ABCP outstanding.

The opportunity cost of DW stigma relative to the ABCP market for bank i and quarter q is then defined as:

$$\text{Cost-ABCP}_{iq} = \text{ABCPcommit}_{iq} * \text{ABCPSpread}_q \,, \tag{5}$$

where ABCPSpread_q is the quarterly average of the daily realized DW stigma premium:

$$\text{ABCPSpread}_t = (\text{ABCP}_t - \text{DW}_t) * I_{\text{ABCP}_t > \text{DW}_t} \tag{6}$$

and ABCP_t is the ABCP market rate on day t for the one-month tenor.

4. Empirical results

To establish DW stigma, we focus exclusively on the first 21 TAF auctions for 28-day funding conducted between December 17, 2007 and September 22, 2008.[15] We concentrate on this period because none of the subsequent TAF auctions were fully subscribed after the Fed doubled the amounts allocated at TAF to \$150 billion on October 6, 2008. As a result, the TAF borrowing rate was not determined competitively for the remainder of the TAF program. In this context, the information content of the bids submitted can be considered meaningless since the bids did not affect the auction stop-out rate.

In the first subsection, we provide descriptive statistics. In the second subsection, we document empirical evidence for the existence of DW stigma using the bidding behavior at TAF auctions. The next subsections provide estimates of the size of the DW stigma premium, while a final subsection reports the economic cost of DW stigma.

4.1. Descriptive statistics

We report in Table 2 descriptive statistics of asset size, as well as (on a per-borrower per-day basis) outstanding TAF borrowings, outstanding DW borrowings, outstanding ABCP issuances, and repo borrowings (subject to legal limits of fund transfers between BHC affiliates). The first three rows of the table show statistics for banks that bid at TAF during our sample period. A total of 185 banks bid in at least one of the 21 TAF auctions in our sample. For the 178 TAF bidders with asset data available, the average asset size was about \$56 billion. On average, the amounts outstanding at TAF (around \$730 million) were larger

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[15] There were also two 84-day TAF auctions towards the end of our sample, on August 11, 2008 and September 8, 2008. Given the newness of the 84-day TAF program, the small number of auctions, and the relatively small amounts auctioned, we do not include these auctions in our sample.

than at the DW (around $120 million). This difference was even larger for the typical bank, as the median amount outstanding at TAF and at the DW was $100 million and $4 million, respectively. ABCP outstanding of TAF bidders (about $270 million) was similar to their repo borrowings (about $210 million). The majority of TAF bidders (118 out of 185) also borrowed at least once from the DW during our sample period, while the remaining 67 banks only bid at TAF. The characteristics of banks that bid at TAF and borrowed at the DW were similar to those of banks that only bid at TAF with respect to funding from the TAF, and the ABCP and repo markets.

The last two rows of Table 2 show descriptive statistics for the 47 banks in our sample with positive ABCP outstanding in any quarter and the 14 banks with dealer affiliates that had positive repo borrowings in any day. Overall, the banks with positive financial market borrowings were larger and borrowed more from TAF. In particular, banks with positive ABCP outstanding (repo borrowings) had an average asset size that was about three times (eight times) larger than the average asset size of TAF bidders.[16]

Before testing for DW stigma, we explain why some banks may participate at both TAF and the DW even if there is DW stigma. One reason TAF bidders may borrow from the DW is because it provides sufficient interest savings on occasional short-term loans (i.e., shorter than a TAF loan of 28 days) to offset the potential costs of DW stigma. We find that the typical DW borrower in our sample took two DW loans during our sample period, typically for an overnight maturity.[17] Therefore, compared to the TAF, banks used the DW to occasionally borrow for shorter durations. Did the overnight duration of a typical DW loan imply lower interest payments compared to TAF borrowings? To examine this

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[16]These comparisons remain valid when we only consider the 42 (out of the 47) banks with ABCP outstanding that were also TAF bidders, and the 13 (out of the 14) repo borrowers that were also TAF bidders.

[17]The median (mean) number of DW loans per bank in our sample was 2.00 (3.25), and the median (mean) length of DW loans was one day (eight days). The length of DW loans is measured as the number of successive days that a bank had positive DW loans outstanding.

question, we calculate the interest payments each DW borrower in our sample would have paid if it had borrowed the same amount from the TAF instead of from the DW.[18] We find that the average interest savings from borrowing at the DW rather than at the TAF were considerable, amounting to 121% of the interest actually paid at the DW. In other words, for every $1 in interest a bank paid for a DW loan, it would have had to pay $2.21 of interest if instead it had taken the same loan from the TAF. In summary, some TAF participants occasionally borrowed from the DW when they had short-term funding needs, typically for one day, which proved highly cost-effective compared to borrowing at the TAF.

4.2. Is there DW stigma?

We plot in Fig. 2 (left panel) the fraction of banks participating at a TAF auction that bid above the prevailing DW rate. This fraction is greater than zero in all but two auctions implying that at least one bank bid above the DW rate at virtually every TAF auction in our sample. Between March and October 2008, the fraction of banks bidding above the DW rate was large (more than 55%) with a generally increasing trend.[19] Out of the 1,540 bank-auction pairs in the sample, bids above the DW rate occurred 56% of the time on average. We interpret this result as conclusive evidence of DW stigma.

A possible objection to our reasoning is that, in the absence of DW stigma, a bank could use a dominated strategy consisting in bidding above the DW rate if the expected cost of doing so is low. Such a situation occurs if, with high probability, the bank expects the

[18]Specifically, we first calculate a bank's maximum DW amount outstanding in the period between two TAF auctions. Then, we assume that the bank borrows this maximum DW amount from the first of the two TAF auctions at the stop-out rate. Finally, we compare the interest payment on this hypothetical TAF loan with the actual interest payment at the DW.

[19]The sharp increase in the fraction of banks bidding above the DW rate in March 2008 may be explained by the Fed reduction in the DW penalty rate on March 16, 2008. Indeed, lowering the DW penalty makes borrowing from the DW more affordable. All else equal, more banks are now willing to pay more than the new DW rate and thus become more likely to bid above the new DW rate.

stop-out rate to be below the DW rate. Fig. 2 provides evidence to refute this argument. Indeed, after March 16, 2008, most TAF auctions in our sample settled above the DW rate (indicated by solid circles in the left panel of Fig. 2). In other words, for a sustained period of time in 2008, borrowing funds from the Fed was actually less expensive at the DW than at the TAF. Thus, banks bidding high at the TAF during this period faced a high probability that their borrowing rate would exceed the DW rate.

Moreover, it does not appear that bids above the DW rate could be explained by occasional bidding mistakes. The right panel of Fig. 2 describes the distribution of the percent of auctions in which a bank bid above the DW rate. It shows that some banks tended to repeatedly bid above the DW rate. In particular, the median vertical line in the right panel of Fig. 2 shows that half of the banks that submitted a bid above the DW rate did so at two-thirds or more of the TAF auctions at which they participated (on average, this group of banks participated at more than eight of the 21 auctions in our sample). Further, although not reported in the figure, we find that 38 out of the 185 TAF participants in our sample submitted bids above the DW rate at every auction at which they participated.

In summary, we find that, during our sample period, bidding at the TAF above the prevailing DW rate was frequent, widespread, and occurred even at auctions where the stop-out rate could be expected to exceed the DW rate. These results provide strong evidence of the existence of DW stigma during the 2007–2008 financial crisis.

4.3. Magnitude of DW stigma premia

The realized DW stigma premium with respect to TAF, averaged over all banks bidding at a TAF auction, is reported in the second column of Table 3. The average realized DW stigma premium was 44 bps. During the 13 auctions conducted between March 24, 2008

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and September 9, 2008 (when TAF was generally more expensive than the DW), the average realized DW stigma premium was 35 bps and then jumped to 143 bps after Lehman Brothers filed for bankruptcy. To understand this jump, recall that at the time there was intense speculation about the identity of the next bank that might fail. It appears natural that in those times of heightened tension and scrutiny, banks were willing to go to great expense to avoid showing any signs of weakness.

We plot in Fig. 3 the average realized DW stigma premium with respect to TAF (solid line) with auction dates marked by circles. We find that, except for the auction conducted just after the bankruptcy of Lehman Brothers, the average realized DW stigma premium is relatively stable. In particular, it remained virtually unchanged during the 13 auctions conducted in summer 2008 prior to the failure of Lehman Brothers.

The realized DW stigma premiums with respect to financial markets are reported in the last two columns of Table 3. The estimates are of similar magnitude to the DW premium with respect to TAF. For the full sample, the average realized DW stigma premium relative to TAF, ABCP, and repo markets was 44, 42, and 46 bps, respectively. In the days after Lehman bankruptcy, the ABCP and repo stigma premiums jumped to 117 bps, similar to the sharp rise in the TAF-based DW stigma premium.

We plot in Fig. 3 the realized DW stigma premium with respect to the repo (dashed line) and the ABCP (dotted line) markets, with observations marked by squares and triangles, respectively. The three measures of the realized DW stigma premium generally followed a similar pattern: they were lower between January 1, 2008 and March 16, 2008 (the date at which the DW penalty rate was reduced), relatively stable following this period until the Lehman bankruptcy, and rose sharply in the days thereafter. There are, however, two noticeable differences between the three measures: the ABCP-based DW stigma premium was relatively high in December 2007, while the repo-based DW stigma premium was lower

in the weeks before the failure of Lehman Brothers.[20]

To gauge the robustness of the results presented in this section, we conducted several exercises.[21] First, we estimated the realized DW stigma premium relative to the three-month ABCP rate, and found that the one-month and three-month ABCP-based DW stigma premiums are of similar magnitude. Second, we explored whether our estimates for the three measures of DW stigma premium are affected by the fact that they are calculated using different samples of banks (e.g., not all TAF bidders issued ABCP or had dealer affiliates with repo borrowings). To do so, we re-estimated the three measures for the subset of banks with positive repo borrowings or positive ABCP outstanding and found the estimates to be of similar magnitudes for the different samples of banks. Finally, we explored the possibility of endogeneity, whereby the mere introduction of the TAF may have affected DW stigma. A comparison of the magnitude of DW stigma with respect to the repo and ABCP markets before and after the introduction of the TAF indicates that the TAF neither created nor increased DW stigma. Thus, our estimates are valid lower bounds of DW stigma.

In summary, we find that the magnitude of the realized DW stigma premium was re-markably robust to different funding sources and different samples of banks. In particular, we do not identify a downward bias in our estimates of the TAF-based DW stigma premium, consistent with the idea that the TAF was effectively designed to reduce the stigma of borrowing from the Fed.

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[20]The first difference was likely due to the sharp increase in ABCP yields during the run on the ABCP market in December 2007 [see Fig. 3 in Kacperczyk and Schnabl (2010)]. The second difference may reflect the impact of the Fed's Term Securities Lending Facility intended to reduce stress in the repo market.

[21]The detailed results of these exercises are reported in the online appendix.

4.4. The economic cost of DW stigma

Estimates for the opportunity cost of borrowing at the TAF instead of the DW are reported in Panel A of Table 4. We first discuss the potential cost of DW stigma, that is, how much more TAF participants risked paying in interest by bidding at the TAF instead of going to the DW. We find that the potential cost was $300 million per auction on average for the full sample, or $6.56 million per auction for each bank that experienced DW stigma. When expressed in relative terms, the potential cost for the full sample represented 14% of the potential interest payments (i.e., the amount of interest the bank would have had to pay if awarded the bid amount at its bid rate).

To assess the effect of DW stigma on banks' performance, we report the reduction in the pre-tax ROA due to stigma which indicates the decrease in before-tax profits, as a percent of assets, due to the additional interest payments incurred in avoiding the DW.[22] We find that the annualized reduction in pre-tax ROA due to the potential stigma cost was 37 bps during our sample. How much would DW stigma cost have decreased pre-tax ROA if it had been incurred during normal times? Considering 2006 as a normal period, we calculate the DW stigma cost in quarter q of 2008 relative to assets in quarter q of 2006 for $q = 1, 2, 3$. We find that the potential cost would have decreased pre-tax ROA in 2006 by 67 bps on average—the larger effect relative to the crisis period is because most banks had smaller book value of assets in 2006. By comparison, the Fed's Capital and Loss Assessment under Stress Scenarios (CLASS) model projected that, if the crisis of 2007 were to reoccur between 2014 and 2016, the pre-tax ROA for US commercial banks would decrease by about 80 bps annually (Hirtle et al., 2014).

During summer 2008, when TAF funding was consistently more expensive than DW

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[22]See Appendix Appendix A.2 for further details. In the online appendix, we also report stigma costs as a ratio of before-tax profits.

funding, the potential cost was $238 million per auction, $4.10 million per bank per auction, or 12.5% of potential interest payments.[23] All of these measures increased greatly at the auction that followed the bankruptcy of Lehman Brothers. Indeed, the potential cost per auction rose by an order of magnitude to $2.50 billion at the Lehman auction, which, when expressed in relative terms, corresponds to 35% of banks' potential interest payments.

We also report in Panel A of Table 4 the realized cost of DW stigma, that is, how much more a bank actually paid in interest by borrowing at the TAF instead of the DW. We find that, in accordance with intuition, it was generally smaller than the potential cost. For example, during summer 2008, the realized cost per auction was almost three times smaller than the potential cost ($85 million compared to a potential cost of $238 million). Nevertheless, the realized cost of DW stigma represents an economically significant amount for banks. For the full sample, we find that, by going to the DW instead of the TAF, banks could have saved 7.5% in interest payments and thereby increased their pre-tax ROA by 17 bps (equivalent to 30 bps of pre-tax ROA during normal times). For the Lehman auction, the realized cost amounted to 40% of banks' actual TAF interest payments.

Panel B of Table 4 reports the opportunity cost of borrowing from the ABCP and repo markets instead of from the DW. The repo-based estimates are aggregated to the quarterly level to facilitate comparisons with the ABCP-based measures. In addition, we report the repo-based estimates for the two days that followed the failure of Lehman Brothers. The opportunity cost with respect to the ABCP market was large, consistent with the fact that the ABCP issuers were big banks with sizeable ABCP outstanding (see Table 2). The per-quarter average cost was about $2 billion and the cost per bank per quarter was more than $62 million. Expressed in relative terms, the ABCP-based opportunity cost of DW stigma was almost 12% of interest payments during our sample period, corresponding to 25 bps of

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[23]Since asset data are at the quarterly level, but the subsample periods are defined using auctions, we do not report changes in the pre-tax ROA for the subsamples in Panel A.

assets (37 bps of assets during normal times). These figures remained relatively stable over the first three quarters of 2008.

As compared to the ABCP-based cost, the aggregate cost with respect to repos was smaller in magnitude, partly reflecting the smaller number of banks with repo borrowings compared to ABCP issuances in our sample (see Table 2). Nevertheless, the cost relative to interest payments (the only measure directly comparable across funding sources as it does not depend on the aggregate amount borrowed) is remarkably similar (between 12% and 18% for both markets depending on the sample period). Further, similar to the post-Lehman TAF auction, the interest payment banks would have saved by borrowing at the DW instead of on the repo market increased sharply to 35% in the two days after the failure of Lehman Brothers.

To conclude, note that a bank's opportunity costs of DW stigma are cumulative over the three funding sources and over time. In particular, the banks that combined TAF and ABCP borrowings during our sample period would have saved a total of $3.4 billion (or 32 bps of their assets) if instead they had borrowed at the DW. In other words, the economic costs of DW stigma were substantial during the financial crisis of 2007 and 2008, as banks could have lowered their interest expenses considerably by borrowing from the DW instead of the TAF or the financial markets.

5. Determinants of DW stigma with respect to TAF

Having documented the existence and magnitude of DW stigma, we now explore the factors that may influence the incidence and magnitude of DW stigma. In doing so, we test some hypotheses related to factors that may exacerbate or attenuate a bank DW stigma on

a given day. We conduct the analysis using the TAF data.[24]

5.1. Empirical methodology

The econometric analysis in this section is based on a series of reduced-form panel data models of the form:

$$Y_{it} = a \times X_{it} + b \times \text{DW}_{it} + c \times \text{TAF}_{it} + d \times M_t + \epsilon_{it} \, , \tag{7}$$

where the subscripts i and t refer respectively to bank i and auction t, Y_{it} is the endogenous variable, X_{it} is a vector that captures characteristics of bank i at auction t, DW_{it} is a vector that reflects bank i borrowing patterns at the DW, TAF_{it} captures bank i participation at the previous TAF auction, M_t includes proxies for market funding conditions prior to the TAF auction, and $\epsilon_{it} = \alpha_m + u_{it}$ where α_m is a month fixed effect and u_{it} is a traditional error term (the exact definitions of the variables are given in Appendix Appendix A.2). When studying the incidence of DW stigma (i.e., whether or not a bank bids above the DW rate), we estimate a probit panel regression with a latent variable model of the form (7). When studying the magnitude of DW stigma, we estimate a linear panel regression model of the form (7) in which the endogenous variable is the TAF-based realized DW stigma premium.

The vector of characteristics for bank i at auction t, X_{it}, includes a measure of the bank size (*Log of assets*), a dummy (*Non-US*) equal to one when the bank is a branch or an agency of a foreign institution, and *Total deposit ratio*, the ratio of a bank's retail funding to its total funding (including market funding from federal funds and repurchase agreements). These variables allow us to test whether DW stigma differs across banks depending on their size,

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[24]We do not carry out similar analyses with the ABCP data (because we do not have bank-level ABCP rates) or the repo data (because the data are time-stamped at the monthly level for most of the sample).

on their country of origin, or on their reliance on wholesale debt investors (such as money market funds) who are highly sensitive to credit risk.[25] We also include a dummy variable, *NY district bank*, for the banks located in the second (New York) district, the largest of the 12 Federal Reserve districts in terms of the number of banks supervised. Out of the 185 banks in our sample, 59 belonged to the New York district. This variable allows us to test the hypothesis formulated by Duke (2010) whereby DW stigma is greater for banks outside the New York district because it is easier to detect their DW borrowing from the weekly aggregate statistics published by their regional Federal Reserve Banks. If the identities of DW borrowers from the New York district are harder to infer, then the coefficient on *NY district bank* should be negative. Finally, we explore whether a bank's financial condition affects its DW stigma. To do so, we include two measures. The first, *CAMELS rating*, is the composite supervisory rating of a bank's overall condition at the time of a TAF auction. These ratings are assigned by the bank's regulator (the Fed, the Office of the Comptroller of the Currency (OCC), or the FDIC) based on confidential supervisory information. The Capital Adequacy, Assets, Management Capability, Earnings, Liquidity, and Sensitivity (CAMELS) ratings range from 1 (strong performance) to 5 (critically deficient). A bank must have a rating of 1, 2, or 3 to borrow primary credit at the DW and TAF. The second, *Quasi-market value of leverage*, is defined as the market capitalization of bank's equity divided by the sum of the market value of equity and the book value of debt. This variable may be viewed as market participants' perception of the bank's financial strength at the time of the TAF auction. Because we only observe the leverage measure for roughly half of our sample, we examine the effect of bank conditions in the final regression specifications.

The vector DW_{it} consists of variables controlling for a bank's access to the DW. In particular, *# Of days in last week bank had DW loan* is the number of days during which a

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[25]See, e.g., Hrung and Sarkar (2012) and 2011 *ECB Financial Stability Review*, available at http://www.ecb.eu/pub/pdf/other/financialstabilityreview201106en.pdf.

bank had an outstanding DW loan in the week prior to a TAF auction. Our hypothesis is that a bank that recently visited the DW should not feel as much DW stigma.[26] Relatedly, we also test the hypothesis that the stigma attached to borrowing at the DW declines when more banks recently accessed the DW. To do so, we include two variables for bank i, *# Of banks taking DW loans week before*, that refers to the number of banks that received DW loans in the week prior to a TAF auction, and *% Of banks within district taking DW loans week before*, that refers to the percentage of banks within bank i's Federal Reserve district that received DW loans in the week prior to a TAF auction. Further, we test whether there is a form of herding or contagion effect, whereby a bank's DW stigma declines when more banks within its own peer group go to the DW. To do so, we partition the banks in our sample in two groups depending on whether they are below or above the median asset size. We then define two variables for bank i, *# Of peers taking DW loans week before*, the number of banks within bank i's asset-size peer group that received a DW loan in the week prior to a TAF auction, and *% Of peers within district taking DW loans week before*, the percentage of peer banks (as measured by asset size) within bank i's Federal Reserve district that received a DW loan in the week prior to a TAF auction. Finally, we include a dummy variable *DW and TAF* for banks that borrowed both at the DW and at the TAF during our sample period. The objective is to test whether this group of banks exhibits specific DW stigma.

The vector TAF_{it}, which controls for a bank's participation at the preceding TAF auction, includes three dummy variables: *Bank bid at previous auction*, *Awarded funds at previous auction*, and *Bid above DW at previous auction* which are equal to one when, at the previous TAF auction, a bank, respectively, i) submitted a bid, ii) received funds, and iii) bid above the DW rate. These variables help us gauge whether a bank's DW stigma may be related to its prior TAF participation. In particular, a positive parameter associated with *Bid above*

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[26]We are not implying causality. Borrowing at the DW may lower a bank stigma at the next TAF auction. Conversely, a bank with lower stigma is more likely to borrow from the DW before a TAF auction.

DW at previous auction would imply that a bank's DW stigma is persistent. Likewise, a positive parameter associated with *Bank bid at previous auction* would imply that returning TAF bidders are more likely to experience stigma.

The market variables in M_t capture aggregate funding conditions and volatility in financial markets on the day prior to a TAF auction. *LIBOR-OIS spread* is a stress indicator for the London Interbank Overnight Rate (LIBOR) and money markets. *VIX* is the forward-looking volatility of the US stock market as implied by options prices. It is generally considered to be a reasonable proxy for "risk aversion" in financial markets. *CDX* is the CDX IG index of Credit Default Swap (CDS) prices, and it measures economy-wide default probability. Following Vives (2014), we expect the parameters associated with these variables to be positive. Indeed, Vives (2014) argues that an increase in financial market stress indicators raises the probability of a crisis and amplifies the impact of news that may be considered negative (such as a DW visit). Finally, to pick up a possible shift in DW stigma at the apex of the crisis, we include a dummy, *Lehman failure*, for the TAF auction that occurred just after the failure of Lehman Brothers.

5.2. Incidence of DW stigma

We first consider probit panel regressions in which the dependent variable Y_{it} in Eq. (7) is equal to one when bank i bids above the DW rate at TAF auction t. To better appreciate the relative effect of each group of explanatory variables, we add them in sequence to the regressions. The estimated marginal effects are reported in Table 5.

We start in column 1 with a model including only the banks' individual characteristics X_{it}. We find that a_1 and a_2 are not significant, while a_3 is positive and significant. Thus, it appears that the incidence of DW stigma was unaffected by a bank's size or total deposit

ratio, while branches and agencies of foreign banks were almost twice as likely to experience DW stigma. The latter result suggests that, all else equal, foreign institutions were more concerned about the risk of being detected taking a DW loan. We also find that a_4 is negative and significant. This result therefore provides some support to Governor Duke's conjecture that banks within the New York district exhibit lower DW stigma than their counterparts in other districts. More precisely, our results suggest that, all else equal, the incidence of DW stigma was 20% less likely for banks within the second district.

We now turn to column 2 where we add the vector DW_{it} which reflects bank i's borrowing pattern at the DW. As indicated by the estimate of b_1, we find that, consistent with our hypothesis, banks that visit the DW in the week preceding a TAF auction are less likely to bid above the DW rate. In contrast, b_2, is insignificant. Therefore, after we control for a bank's recent DW visits, we find no evidence that the banks that went both to TAF and the DW during our sample period had a different incidence of DW stigma compared to the other banks in our sample. Because the number of banks going to the DW is driven in part by market conditions, we delay the discussion about the effect of the variables capturing possible herding effects until after we introduce controls for market conditions.

In column 3 of Table 5, we report the probit regression results when we account for a bank's bidding behavior at the previous TAF auction. Accordingly, we must drop the first auction in our sample. We find that the estimated value of c_1 is negative and significant. This result therefore suggests that first-time and non-returning TAF bidders are 25% more likely to exhibit DW stigma. Consistent with Section 4.2 where we found that the same banks tend to repeatedly exhibit DW stigma, the regression results reveal a strong persistence in DW stigma. Indeed, the significance and magnitude of c_2 in Table 5 suggest that a bank is almost twice as likely to bid above the DW rate if it also did so at the previous auction. Finally, c_3 is positive and significant, thereby indicating that banks that did not receive funds at the

previous TAF auction were the least likely to experience DW stigma. This result reflects the behavior of a few strategic banks that regularly submitted TAF bids at (or near) the minimum bid rate in the event the auction would be undersubscribed (in which case they would have received funds at a very low rate).

Next, we introduce in column 4 of Table 5 the variables controlling for market conditions. The coefficients on the three market risk variables, *LIBOR-OIS spread*, *VIX*, and *CDX*, are all positive and significant. These results therefore support Vives (2014), since the incidence of DW stigma appears more frequent when there is greater stress in financial markets.

Having controlled for market conditions, we now introduce the variables *# Of banks taking DW loans week before* and *% Of banks within district taking DW loans week before* to test the hypothesis that there is less stigma attached to borrowing at the DW when more banks have recently accessed the DW. The results reported in column 5 of Table 5 indicate that b_3 and b_4 are not significantly different from zero, thereby providing no support for this hypothesis. Likewise, we can see in column 6 that b_5 and b_6 are insignificant, thereby providing no evidence for a herding effect whereby a bank would be less likely to experience DW stigma when more of its peers (as measured by asset size) recently visited the DW.[27]

Finally, we account for the variables *CAMELS rating* and *Quasi-market value of leverage* to test whether banks that are perceived to be in poor financial conditions are more likely to experience DW stigma. As can be seen in columns 7 and 8 of Table 5, a_5 and a_6 are not significant. Thus, we do not find evidence that the incidence of DW stigma was more frequent when banks are in poor financial conditions.

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[27]As shown in the online appendix, the nature of the results presented does not change when we control for bank- and auction-specific random effects, or when we use linear instead of probit regressions.

5.3. Magnitude of the realized DW stigma

To better understand the determinants of the realized DW stigma premium, we estimate linear regressions in which the dependent variable Y_{it} in Eq. (7) is bank i realized DW stigma premium at TAF auction t. We report in Table 6 a similar sequence of specifications as in Table 5.

We find that the incidence and the magnitude of DW stigma generally share the same determinants, except for bank-specific characteristics. Indeed, while foreign banks and banks outside the New York district are more likely to experience DW stigma (see Section 5.2), their realized DW stigma premium is not significantly different from other banks (a_3 and a_4 are insignificant in every specification in Table 6). In contrast, smaller banks and banks that borrowed from the DW and TAF during our sample period tend to have higher realized DW stigma premia, although they are not more likely to exhibit DW stigma. Further, observe in column 8 that a_5 is insignificant, while a_6 is negative and significant. Thus, while we find no evidence that a bank's condition (as measured by the regulator) affects its DW stigma, we find some evidence that the magnitude of realized DW stigma is larger for banks that are perceived to be in poor conditions by market participants. The latter result, however, should be considered with caution as it relies only on roughly half of the sample.

The other parameters generally have the same sign and significance in Tables 5 and 6. In particular, bidding behavior at the previous TAF auction and market risk indicators influence both the incidence and the magnitude of DW stigma. Market conditions, however, are not sufficient to fully explain the magnitude of DW stigma at the apex of the crisis. Indeed, we find a sharp increase of almost 96 bps in the realized DW stigma premium after the bankruptcy of Lehman Brothers (see d_4 in column 4 of Table 6).

To sum up, the regression results presented in this section appear sensible and generally

support our hypotheses about DW stigma. In particular, we find a higher incidence of DW stigma for banks outside the New York district and for foreign banks. In contrast, we find a lower incidence of DW stigma for banks that recently visited the DW. Finally, DW stigma is found to increase when funding markets become stressed.

6.   Conclusion

DW stigma is generally considered an obstacle to the Fed's mission as the lender of last resort, especially during financial crises when the consequences of DW stigma are potentially the most damaging. However, DW stigma is not a well-understood phenomenon. In fact, empirical evidence of DW stigma has been scarce to nonexistent. In this paper, we take advantage of a unique episode (the introduction of the TAF as an alternative to the DW) to examine empirically the existence, magnitude, and economic cost of DW stigma during the financial crisis of 2007–2008.

We find strong evidence of DW stigma as most banks regularly submitted TAF bids above the prevailing DW rate. Moreover, we find that banks were willing to pay a premium in excess of 44 bps on average to borrow from the TAF instead of the DW. Immediately after the failure of Lehman Brothers, at the apex of the crisis, this premium increased sharply to at least 143 bps. These results appear robust as we obtain similar magnitudes when evaluating DW stigma with respect to two financial markets (the ABCP and the repo markets). We also find that DW stigma had substantial economic costs. In particular, if banks had borrowed from the DW instead of the TAF and the ABCP markets, they would have saved $3.4 billion during our sample period thereby increasing their pre-tax ROA by 32 bps. Finally, an econometric analysis suggests several factors that influence DW stigma such as deteriorating market conditions, being a bank located outside the NY district, being

a non-US bank, or market perceptions of the bank's condition. These results support the hypotheses formulated by Vives (2014) and Duke (2010) about possible determinants of DW stigma.

Our results have policy implications on how central banks can supply liquidity effectively. Indeed, because DW stigma is a latent variable that can vary with market conditions and across banks, it is difficult to predict the extent to which the DW rate needs to be adjusted to promote or deter DW borrowing. Although the DW may still have a role to play as an emergency lending facility when a bank cannot find financing in the market for occasional and idiosyncratic reasons, one may question the ability of the DW as a channel to supply liquidity to a broad set of banks after a systemic funding shock. Instead, it may be preferable to complement the DW by designing new "stigma proof" facilities specifically aimed at supplying liquidity to the entire banking sector. This is precisely what the Fed did when it created the TAF. Similarly, the BoE recently adopted a twofold approach: a DW for meeting idiosyncratic liquidity shocks, and a contingency liquidity facility activated in response to exceptional market-wide stress.[28]

An additional policy implication of our results pertains to the transparency of DW borrowing. Indeed, one of the pre-conditions for the existence of DW stigma is that the identity of borrowers may be inferred by market participants. Arguably, the recent initiatives aimed at promoting more transparency about which institutions borrow from the Fed's liquidity programs could enhance DW stigma. Recognizing the possible adverse consequences of real-time disclosure, the Dodd-Frank Act of 2010 requires the Fed to reveal the identity of DW borrowers only after a lag of two years. Likewise, to mitigate DW stigma, the BoE has recently extended its DW disclosure lag to five quarters.[29]

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[28]See, in particular, Bank of England (2013).
[29]See again, Bank of England (2013).

Understanding DW stigma is also important to effectively implement monetary policy in normal times. Many central banks set a "corridor"around their target rate. The floor of the corridor is the standing deposit facility rate (or the interest on excess reserves, in the Fed's case) and the ceiling is the standing borrowing facility or DW rate.[30] In principle, banks have no incentives to borrow above the ceiling or lend below the floor. Thus, the corridor system enables central banks to limit the fluctuations in the overnight interbank market rate. As argued by Kahn (2010), however, the ceiling becomes "leaky"when there is DW stigma, in which case the central bank loses its ability to moderate the market rate fluctuations around the target rate.

The relevance of stigma in financial markets may extend beyond the Fed's DW facility. In the US, for example, it has been mentioned that the Primary Dealer Credit Facility (PDCF) and the Term Securities Lending Facility (TSLF) may have been stigmatized (Krishnamurthy, Nagel, and Orlov, 2014; and Acharya et al., 2014). Likewise, some of the institutions that accepted financial assistance through the 2008 Troubled Asset Relief Program (TARP) were subsequently branded as having "TARP stigma."[31] In the international sphere, beyond the case of the BoE previously discussed, the effectiveness of facilities put in place by various central banks has been questioned due to stigma concerns.[32] By establishing the existence of DW stigma and identifying some of its determinants, our paper contributes towards a better understanding of stigma with respect to government programs.

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[30]See, for example, Keister (2012).

[31]See "Move to repay aid helps Bank of America shed stigma," *The New York Times*, December 3, 2009 and NPR, April 1, 2009 (http://www.npr.org/templates/story/story.php?storyId=102618967).

[32]See "Deutsche Bank concerned by offer of ECB loans," *The Financial Times*, February 2, 2012.

Appendix A.1. Fund transfers from a BHC's banking affiliate to its dealer affiliate

To estimate the repo-based opportunity cost of DW stigma, we assume that the banking affiliate of the BHC transfers funds to its dealer affiliate. Specifically, the banking affiliate offers a loan to its dealer affiliate, equal to the desired amount of repo borrowing, against collateral eligible at the DW. In turn, the banking affiliate borrows from the DW against the collateral received from its dealer affiliate. However, the amount of such inter-affiliate transfers is restricted by law. Specifically, the Federal Reserve Act Section 23-A restricts the aggregate amount outstanding of internal fund transfers with any affiliate to 10% of the capital stock and surplus of the BHC. Exceptions are repo borrowing based on Treasury and Agency securities, which are unrestricted. Moreover, Section 23-A provisions do not apply to non-US banks.[33] We now describe the implementation of Section 23-A restrictions in estimating the opportunity cost of DW stigma relative to repo markets.

For US banks, denote the daily average of repo funding based on non-Treasury and non-Agency collateral during a month as:

$$\text{Repo xTxA}_{im} = \frac{1}{\text{Days}_m} \sum_{c=1}^{N_{im}} \text{URepoAmt}_{cim}, \tag{A.1}$$

where, for dealer i in month m, N_{im} is the number of non-Treasury, non-Agency collateral types pledged by the repo borrower, Days_m is the number of trading days in month m, and URepoAmt_{cim} is the unrestricted repo funding based on collateral c (different than Treasury and Agency).

Per Section 23-A, $0.10 * \text{Surplus}_{iq}$ is the cap on how much a dealer can receive from its banking affiliate, where Surplus_{iq} is the sum of the bank's capital stock and surplus in quarter q, as defined in regulation 12 CFR 223.3(d). Specifically, Surplus_{iq} is defined as: (1) a member bank's tier 1 and

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[33]See http://www.federalreserve.gov/aboutthefed/section23a.htm and http://www.law.cornell.edu/cfr/text/12/223.42).

tier 2 capital; (2) the balance of a member bank's allowance for loan and lease losses not included in its tier 2 capital; and (3) the amount of any investment by a member bank in a financial subsidiary that counts as a covered transaction (i.e., investment in affiliate's securities or loan to affiliate) and is required to be deducted from the member bank's capital for regulatory capital purposes. Data for items (1) and (2) are obtained from Call Reports. We do not have data for item (3), so our estimate of the surplus should be considered conservative.

We assume that the aggregate monthly repo borrowings occurred uniformly over each day of the month and so the daily outstanding is Repo xTxA$_{im}$. Since these are overnight repos, the Section 23-A cap applies to the *daily* amount of repo outstanding.

When the daily cap is not reached (i.e., Repo xTxA$_{im}$ < $0.10 * \text{Surplus}_{iq}$), we define the amount of legally allowed repo funding for bank i, collateral c, in month m as:

$$\text{RepoAmt}_{cim} = \text{URepoAmt}_{cim}. \tag{A.2}$$

Otherwise, when the Section 23-A cap is breached, we reduce the unrestricted repo amounts for each collateral proportionately:

$$\text{RepoAmt}_{cim} = \text{URepoAmt}_{cim} * \frac{0.10 * \text{Surplus}_{iq}}{\text{RepoxTxA}_{im}}. \tag{A.3}$$

For the daily data, we check if RepoxTxA$_{id}$, the unrestricted repo borrowing on day c based on non-Treasury and non-Agency, exceeds 10% of $Surplus_{iq}$ and, if so, we reduce $URepoAmt_{cid}$ proportionately. Thus, for bank i, collateral c, and day d:

$$\text{RepoAmt}_{cid} = \text{URepoAmt}_{cid} * \frac{0.10 * \text{Surplus}_{iq}}{\text{RepoxTxA}_{id}}. \tag{A.4}$$

Appendix A.2.   Data and variable descriptions

The TAF data cover the period December 17, 2007—the start of the TAF facility—to September 22, 2008—the first auction after the collapse of Lehman Brothers and the last oversubscribed auction. The TAF bid data are from the Federal Reserve Bank of New York. They contain observations of bid amounts and bid rates for all bids submitted by banks at TAF auctions. In addition, the publicly available TAF data (available from http://federalreserve.gov/newsevents/ reform_taf.htm) include the award amounts per bank and the stop-out rates at each auction. Data on DW borrowings for our sample period have been released by the Fed (see http://tinyurl.com/ b8nbj7c). We use DW activity data from August 1, 2007 to September 22, 2008.

CAMELS rating are confidential supervisory information obtained from the Federal Reserve Board of Governors. The quasi-market value of leverage is market capitalization of the bank's equity, divided by the sum of the market value of equity plus the book value of its debt. This variable is only observed for publicly listed firms. For domestic banks, total deposits are item 2200 on the call report ("total deposits"). For foreign banks, total deposits are "total deposits and credit balances" (item 2205 on the Report of Assets and Liabilities of U.S. Branches and Agencies of Foreign Banks (FFIEC002)) minus "total credit balances" (item 2552 on FFIEC002). The total deposit ratio is total deposits divided by total deposits + federal funds purchased (RCONB993) + repurchase agreements (RCONB995).

Bank asset values and earnings before tax (EBT) are obtained from the Fed's Call and Thrift Reports. EBT are derived from net income by adding back taxes and subtracting off *Extraordinary items net of taxes*. In a given quarter, a bank's actual $Pre\text{-}tax\,ROA = \frac{EBT}{Assets}$, whereas its hypothetical $Pre\text{-}tax\,ROA\,without\,DW\,stigma = \frac{(EBT+DW\,stigma\,cost)}{Assets}$, and so the change in pre-tax ROA due to stigma is $\frac{DW\,stigma\,cost}{Assets}$.

A bank's liquidity commitments to its ABCP conduit are defined as unused commitments to provide liquidity to conduit structures, including conduits sponsored by the bank, a bank affiliate,

or the bank's holding company. The data for US banks are from the Call Reports and from the Y9C data, while that for foreign banks are from the FFIEC002 data.

The repo data were provided to Copeland, Martin, and Walker (2011) by a large investor in the repo market and consist of repo transactions of dealers who received funding from this investor. The data are from January 2007 to September 2008. Transactions are time-stamped for the end of each month, except for the September 2008 data which are daily. For each transaction, we observe the identity of the repo borrower, the associated collateral, the repo rate, and repo amount.

The US LIBOR rates (one-month maturity) are from the British Banker's Association. The Overnight Indexed Swap (OIS)—also one-month maturity—and VIX are obtained from Bloomberg. The five-year CDX IG index is obtained from Markit. The policy variables, namely, the Fed funds target and the DW penalty rate, are obtained from the Federal Reserve Board.

Table B.1 provides a concise description of the variables used in the empirical analysis. Summary statistics of the variables appear in Table B.2.

Table B.1

Description of variables used in the regressions

Log of assets	Log of the quarterly asset value as reported in Call Reports
Total deposit ratio	The bank's total deposits divided by (total deposits + federal funds purchased + repurchase agreements)
Non-US	Dummy variable equal to one if the bank is a branch or an agency of a foreign bank
NY district bank	Dummy variable equal to one if the bank is headquartered in the second (New York) Federal Reserve District
CAMELS rating	The bank's composite rating of overall condition as assigned by its regulator (the Fed, OCC, or FDIC)
Quasi-market value of leverage	The market capitalization of the bank's equity, divided by the sum of the market value of equity plus the book value of its debt
# Of days in last week bank had DW loan	Number of days that a bank had DW loans outstanding in the week prior to the TAF auction
DW and TAF	Dummy variable equal to one for banks that borrowed from both DW and TAF during our sample period
# Of banks taking DW loans week before	Total number of TAF eligible banks that received DW loans in the week prior to the TAF auction
% Of banks within district taking DW loans week before	Percentage of TAF eligible banks in district that received DW loans in the week prior to the TAF auction
# Of peers taking DW loans week before	Total number of TAF eligible banks above (below) the median asset size that received DW loans in the week prior to the TAF auction when the bank is above (below) the median
% Of peers within district taking DW loans week before	Percentage of TAF eligible banks in district above (below) the median asset size that received DW loans in the week prior to the TAF auction when the bank is above (below) the median asset size
Bank bid at previous auction	Dummy variable equal to one if the bank bid at the previous TAF auction
Awarded funds at previous auction	Dummy variable equal to one if the bank was awarded funds at the previous TAF auction
Bid above DW at previous auction	Dummy variable equal to one if the bank bid above the DW rate at the previous TAF auction
LIBOR-OIS spread	Difference between the LIBOR and OIS rates of one-month maturity
VIX	VIX volatility index of Standard & Poor (S&P) 500 returns
CDX	CDX IG index of CDS prices of five-year maturity
Lehman failure	Dummy variable equal to one for the September 22, 2008 TAF auction and zero otherwise

Table B.2

Summary statistics of variables used in Regressions

Variable	Number of observations (Bank-auction pairs)	Mean	Median	Standard deviation	Min	Max	Dummy variable? (Y/N)
Log of assets ($ billion)	1,508	9.74	9.81	1.89	4.87	14.16	N
Total deposit ratio	1,499	0.85	0.91	0.18	0	1	N
Non-US	1,540	0.38	0	0.49	0	1	Y
NY district bank	1,540	0.41	0	0.49	0	1	Y
CAMELS rating	1,491	1.91	2	0.51	1	3	N
Quasi-market value of leverage	707	0.11	0.09	0.08	0	0.74	N
# Of days in last week bank had DW loan	1,540	0.12	0	0.57	0	5	N
DW and TAF	1,540	0.63	1	0.48	0	1	Y
# Of banks taking DW loans week before	1,540	43.88	39	19.15	19	101	N
% Of banks within district taking DW loans week before	1,540	5.65	5.41	3.79	0	20.69	N
# Of peers taking DW loans week before	1,511	24.57	22	9.42	5	51	N
% Of peers within district taking DW loans week before	1,511	5.99	5.41	4.43	0	33.33	N
Bid at previous auction	1,540	0.66	1	0.48	0	1	Y
Awarded funds at previous auction	1,540	0.40	0	0.49	0	1	Y
Bid above DW at previous auction	1,540	0.37	0	0.48	0	1	Y
LIBOR-OIS spread (in %)	1,540	0.51	0.46	0.18	0.23	0.85	N
VIX	1,540	0.23	0.23	0.04	0.16	0.32	N
CDX	1,540	93.51	93.14	3.25	86.40	98.68	N
Lehman failure	1,540	0.06	0	0.23	0	1	Y

Table 1

Comparison between the TAF and the DW

	Term Auction Facility	Discount Window (Primary Credit)
Panel A: Similarities		
Collateral and haircut	Same collateral and haircut calculations as DW[a]	Same collateral and haircut calculations as TAF
Eligibility	Banks eligible for primary credit at the DW and with enough collateral to make the minimum TAF bid	Banks with reserve account and high supervisory rating are eligible for primary credit at the DW[b]
Identification	Identities of TAF participants were not revealed until December 1, 2010	Identities of DW borrowers were not revealed until December 23, 2011
Panel B: Differences		
Frequency	Generally once every two weeks	Any time during normal business hours
Minimum bid or loan amount	$10 million until February 1, 2008, $5 million after that	None
Loan term	Generally 28 or 84 days	Overnight through 30 days before March 16, 2008 and 90 days thereafter, renewable by borrower
Maximum bid or loan amount	10% of total auction size or up to available collateral (whichever is smaller)	Up to available collateral
Prepayment	Not allowed	Allowed without penalty
rate	Determined through competitive bidding at an auction	Spread over Fed funds target rate (target+50 bp until March 16, 2008; target+25 bp thereafter)
Settlement	Credited to the winning bidders three days after the auction	Credited on the same day

[a] 84-day TAF loans, not studied in this paper, required additional collaterization.
[b] For exact DW eligibility criteria, see http://www.frbdiscountwindow.org/discountwindowbook_pf.pdf.

Table 2

Descriptive statistics of TAF bidders, ABCP issuers, and repo borrowers The table shows the mean and standard deviation (in parentheses) of asset size, as well as TAF outstanding per borrower per day, DW outstanding per borrower per day, ABCP outstanding per borrower per day, and repo borrowings per borrower per day. *DW outstanding* is the daily average of the total DW loans outstanding for a bank. *ABCP outstanding* is the daily average of the quarterly unused liquidity commitment of a bank to its ABCP conduits. *Repo borrowing* is the daily average of repo borrowings that can be legally transferred between bank holding company affiliates. The TAF and DW sample is from December 17, 2007 to September 22, 2008 and includes all oversubscribed 28-day TAF auctions. The ABCP and repo samples in this table start on January 1, 2008 and end on September 17, 2008.

	Number of banks	Asset size (billion $)	TAF outstanding (billion $)	DW outstanding (billion $)	ABCP outstanding (billion $)	Repo borrowing (billion $)
Banks that:						
Bid at TAF	185	55.81 (179.34)	0.73 (1.55)	0.12 (0.47)	0.27 (0.35)	0.21 (0.16)
Bid at TAF and borrowed at DW	118	61.22 (187.45)	0.72 (1.60)	0.12 (0.47)	0.27 (0.34)	0.20 (0.11)
Bid at TAF only	67	46.32 (165.15)	0.75 (1.49)	– –	0.26 (0.41)	0.23 (0.24)
Had positive ABCP outstanding	47	171.12 (345.92)	1.63 (2.20)	0.15 (0.57)	0.24 (0.34)	0.21 (0.13)
Had positive repo borrowing	14	422.15 (573.34)	1.98 (2.06)	0.03 (0.02)	0.64 (0.51)	0.23 (0.17)

Table 3

Magnitude of realized DW stigma premium The table shows the mean and standard deviation (in parentheses) for the estimates of the realized DW stigma premium in bps. For a bank that bids above the DW rate, the realized DW stigma premium relative to TAF (heading "TAF") is the bank's highest TAF bid rate minus the DW rate. The realized DW stigma premium relative to the ABCP market is the one-month ABCP rate minus the DW rate, conditional on the spread being positive (heading "ABCP"). The realized DW stigma premium relative to the repo market for a particular collateral is the daily repo rate minus the DW rate, conditional on the spread being positive. The table reports the average over all collateral eligible at the DW (heading "Repo"). The full sample is from December 17, 2007 to September 22, 2008. The repo sample used in this table starts on January 1, 2008. The Summer 2008 sample is from March 24, 2008 through September 9, 2008, except for the repo rate calculations for which it extends monthly from April to August 2008 and daily from September 1 to 9, 2008. Lehman is the single auction on September 22, 2008 for the TAF calculations, and September 16 and 17, 2008, for the ABCP and repo market estimates.

	TAF		ABCP		Repo	
	Obs	Premium (bps)	Obs	Premium (bps)	Obs	Premium (bps)
Full sample	866	44.29 (48.54)	145	42.30 (19.19)	383	46.29 (57.00)
Summer 2008	754	34.74 (23.40)	122	39.51 (9.84)	193	17.16 (14.56)
Lehman	80	142.70 (97.34)	2	117.00 (55.15)	71	116.94 (44.28)

Table 4

Opportunity cost of DW stigma We report opportunity cost for banks with DW stigma relative to TAF in Panel A and relative to the market in Panel B. In Panel A, potential cost is the bank's bid amount times the Bid-DW rate spread, conditional on the spread being positive. Realized cost is the bank's award amount times the stop-out-DW rate spread, conditional on the spread being positive. Cost/Interest paid is the potential (realized) cost divided by the potential (realized) TAF interest payment. In Panel B, the cost relative to ABCP is the bank's ABCP outstanding per quarter times the ABCP-DW rate spread, conditional on the spread being positive. Cost/Interest Paid is the cost divided by the interest that banks would have paid if charged the ABCP market rate on their ABCP amount outstanding. The cost relative to repo is the amount of a bank's repo funding for a collateral times the Repo-DW rate spread, conditional on the spread being positive. Cost/Interest paid is the cost divided by the total interest the bank paid for its repo borrowing. In all panels, *Reduction in pre-tax ROA due to stigma* is the cost divided by total assets and *Reduction in pre-tax ROA due to stigma*$_{2006}$ is the cost in quarter q of 2008 divided by the assets in quarter q of 2006, for q=1, 2, 3. In Panel A, the full sample is from December 17, 2007 to September 22, 2008, the Summer 2008 sample is from March 24, 2008 through September 9, 2008, and Lehman is the single auction on September 22, 2008. In Panel B, "Full sample" indicates the first three quarters of 2008 and the Lehman sample is September 16 and 17, 2008.

Panel A: Cost of borrowing from TAF instead of from DW

| | Potential cost | | | Realized cost | | |
	Full sample	Summer 2008	Lehman	Full sample	Summer 2008	Lehman
Observations	866	754	80	569	538	31
Ave per auction (mil. USD)	299.22	237.98	2,510.75	172.08	85.45	1,125.01
Ave per bank per auction (mil. USD)	6.56	4.10	31.38	3.63	1.75	36.29
Cost / Interest Paid (%)	14.26	12.48	35.00	7.48	5.61	40.00
Reduction in pre-tax ROA due to stigma (%)	0.37			0.17		
Reduction in pre-tax ROA due to stigma$_{2006}$ (%)	0.67			0.30		

Panel B: Cost of borrowing from markets instead of from DW

| | ABCP market | | | Repo market | | | |
	Full sample	Q2 2008	Q3 2008	Full sample	Q2 2008	Q3 2008	Lehman
Observations	96	32	30	450	87	336	71
Ave per quarter (mil. USD)	1,987.69	2,121.85	1,785.67	474.38	280.09	1096.21	284.33[a]
Ave per bank per quarter (mil. USD)	62.12	66.31	59.52	38.46	21.55	84.32	23.69 [b]
Cost / Interest paid (%)	11.68	13.76	13.99	12.16	11.92	18.06	35.00
Reduction in pre-tax ROA due to stigma (%)	0.25	0.27	0.24	0.94	0.43	2.20	
Reduction in pre-tax ROA due to stigma$_{2006}$ (%)	0.37	0.38	0.33	1.02	0.49	2.37	

[a] Average per day
[b] Average per bank per day

Table 5

Determinants of the incidence of DW stigma We report the estimated marginal effects from probit regressions where the dependent variable equals one when a bank submits a TAF bid above the DW rate and is zero otherwise. The specification of the model is given in Eq. (7). The regressors are defined in Appendix Appendix A.2. Each model includes month fixed effects (not reported). The sample includes all bank-auction pairs for 28-day TAF auctions from December 17, 2007 to September 22, 2008. Heteroskedasticity-adjusted robust standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
a_1	Log of assets	-0.01 (0.01)	-0.02 (0.01)	-0.02* (0.01)	-0.02 (0.01)	-0.02 (0.01)	-0.02 (0.01)	-0.02 (0.01)	-0.01 (0.02)
a_2	Total deposit ratio	-0.12 (0.11)	-0.06 (0.11)	-0.03 (0.11)	-0.06 (0.11)	-0.06 (0.11)	-0.05 (0.11)	-0.05 (0.12)	-0.06 (0.41)
a_3	Non-US	0.46*** (0.06)	0.46*** (0.06)	0.33*** (0.07)	0.37*** (0.07)	0.37*** (0.07)	0.37*** (0.07)	0.37*** (0.07)	0.39*** (0.08)
a_4	NY district bank	−0.19*** (0.07)	−0.22*** (0.07)	−0.17** (0.08)	−0.19** (0.08)	−0.18** (0.08)	−0.19** (0.08)	−0.19** (0.08)	−0.16 (0.10)
a_5	CAMELS rating							-0.00 (0.05)	-0.08 (0.07)
a_6	Quasi-market value of leverage								-0.65 (0.42)
b_1	# Of days in last week bank had DW loan		−0.23*** (0.03)	−0.18*** (0.03)	−0.19*** (0.03)	−0.22*** (0.03)	−0.19*** (0.03)	−0.19*** (0.03)	−0.17*** (0.05)
b_2	DW and TAF		-0.02 (0.04)	-0.04 (0.04)	-0.06 (0.04)	-0.05 (0.04)	-0.05 (0.04)	-0.06 (0.04)	-0.01 (0.07)
b_3	# Of banks taking DW loans week before					0.00 (0.00)			
b_4	% Of banks within district taking DW loans week before					0.01 (0.01)			
b_5	# Of peers taking DW loans week before						0.00 (0.00)		
b_6	% Of peers within district taking DW loans week before						-0.00 (0.01)		
c_1	Bank bid at previous auction			-0.25*** (0.05)	-0.30*** (0.05)	-0.30*** (0.05)	-0.30*** (0.05)	-0.30*** (0.05)	-0.32*** (0.07)
c_2	Bid above DW at previous auction			0.48*** (0.04)	0.51*** (0.04)	0.52*** (0.04)	0.51*** (0.04)	0.52*** (0.04)	0.58*** (0.06)
c_3	Awarded funds at previous auction			0.16*** (0.05)	0.18*** (0.06)	0.18*** (0.06)	0.18*** (0.06)	0.18*** (0.06)	0.26*** (0.08)
d_1	LIBOR-OIS spread				1.27** (0.45)	1.20** (0.51)	1.08** (0.48)	1.33** (0.45)	2.22** (0.38)
d_2	VIX				6.02*** (1.63)	5.86*** (1.86)	5.59*** (1.65)	6.04*** (1.63)	4.80*** (1.98)
d_3	CDX				0.15*** (0.04)	0.15*** (0.04)	0.16*** (0.04)	0.14*** (0.04)	0.09*** (0.04)
	Observations	1,499	1,499	1,409	1,409	1,409	1,409	1,398	659
	# Of unique banks	177	177	171	171	171	171	171	74
	Log likelihood	-577.4	-544.8	-432.8	-388.3	-387.2	-387.8	-385.1	-189.0

Table 6

Determinants of realized DW stigma premium with respect to TAF We report linear regressions where the dependent variable is the TAF-based realized DW stigma premium (in bps), defined for banks that bid above the DW rate as the difference between a bank's TAF bid rate and the DW rate. The specification of the model is given in Eq. (7). The regressors are defined in Appendix Appendix A.2. Each model includes a constant term and month fixed effects (not reported). The sample includes all bank-auction pairs for 28-day TAF auctions from December 17, 2007 to September 22, 2008. Heteroskedasticity-adjusted robust standard errors are in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
a_1	Log of assets	−2.53*** (0.73)	−2.92*** (0.74)	−3.00*** (0.74)	−2.96*** (0.66)	−2.92*** (0.67)	−2.75*** (0.71)	−3.00*** (0.70)	−3.28*** (1.01)
a_2	Total deposit ratio	2.94 (10.08)	4.58 (10.06)	7.42 (10.58)	8.71 (9.06)	8.47 (9.11)	8.75 (9.10)	9.06 (9.43)	27.62 (20.76)
a_3	Non-US	5.60 (4.95)	6.95 (4.74)	6.65 (4.83)	7.30 (4.71)	7.26 (4.72)	7.55 (4.75)	7.19 (4.72)	9.76 (6.74)
a_4	NY district bank	3.77 (4.45)	4.93 (4.21)	2.76 (4.36)	-0.27 (4.41)	-0.13 (4.44)	-0.59 (4.50)	-0.19 (4.44)	-0.89 (5.34)
a_5	CAMELS rating							0.64 (2.58)	3.58 (3.50)
a_6	Quasi-market value of leverage								−60.20** (24.95)
b_1	# Days in last week bank had DW loan		-4.37 (4.67)	-3.93 (4.83)	-7.70 (4.96)	-8.07 (5.35)	-7.47 (5.06)	-7.77 (4.96)	0.43 (7.47)
b_2	DW and TAF		10.64*** (3.12)	9.65*** (3.23)	10.33*** (2.75)	10.38*** (2.77)	10.16*** (2.76)	10.46*** (2.77)	12.96*** (3.67)
b_3	# Of banks taking DW loans week before					-0.33 (0.25)			
b_4	% Of banks within district taking DW loans week before					0.14 (0.46)			
b_5	# Of peers taking DW loans week before						-0.32 (0.27)		
b_6	% Of peers within district taking DW loans week before						-0.05 (0.32)		
c_1	Bank bid at previous auction			-5.78 (3.89)	-8.33** (3.42)	-8.40** (3.45)	-8.20** (3.45)	-8.11** (3.45)	-15.68** (5.25)
c_2	Bid above DW at previous auction			6.93* (3.90)	6.09* (3.51)	6.17* (3.54)	5.97* (3.54)	6.27* (3.53)	10.75* (4.98)
c_3	Awarded funds at previous auction			11.93*** (4.32)	15.51*** (3.80)	15.56*** (3.80)	15.54*** (3.81)	15.21*** (3.82)	13.87*** (4.91)
d_1	LIBOR-OIS spread				110.81*** (18.50)	124.08*** (20.37)	122.33*** (21.37)	113.09*** (18.46)	128.69*** (25.58)
d_2	VIX				129.31* (77.30)	122.28 (78.24)	102.11 (81.79)	128.36* (77.67)	118.00 (92.00)
d_3	CDX				-0.59 (1.94)	-2.26 (2.30)	-2.66 (2.68)	-0.69 (1.95)	-0.09 (2.46)
d_4	Lehman failure				96.36*** (12.46)	105.20*** (14.35)	102.37*** (13.95)	96.19*** (12.46)	73.69*** (15.51)
	Observations	831	831	814	814	814	814	810	352
	# Of unique banks	136	136	135	135	135	135	135	59
	Adj R^2	0.27	0.28	0.28	0.48	0.48	0.48	0.48	0.47

Figure 1:

Amount of DW and TAF credit outstanding.
The figure displays weekly averages of the amount outstanding at the TAF (solid line), the hypothetical amount outstanding if all bids submitted at the TAF were accepted (dotted line), and the amount of primary credit outstanding at the DW (dashed line). All series are in billions of US dollars. The source of the data is the *Federal Reserve Statistical Release H.4.1.* The dates of the sale of Bear Stearns and the bankruptcy of Lehman Brothers are indicated by vertical lines.
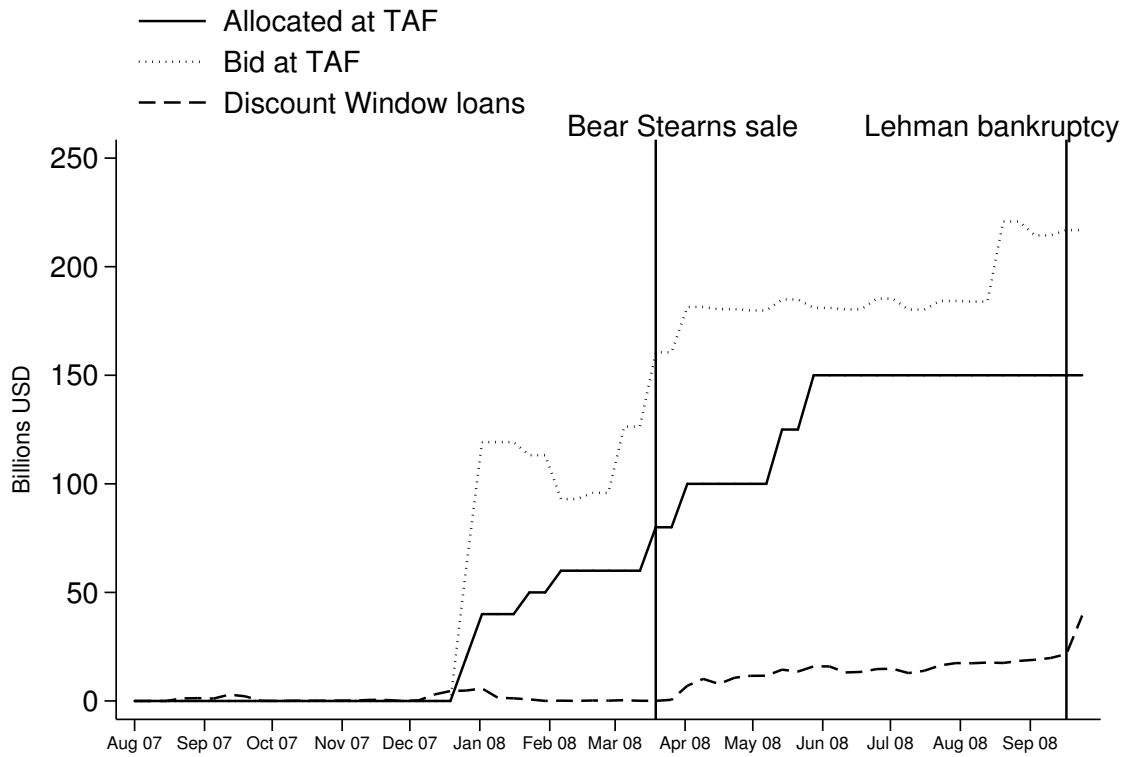
Figure 2:

TAF bids above the DW rate.
The left panel figure shows the share of banks that submit a TAF bid above the DW rate. If a bank submits multiple bids at a TAF auction, only the bid with the highest rate is considered. Auctions with a stop-out rate above the DW rate are indicated by solid circles, while auctions with a stop-out rate below the DW rate have hollow circles. The reduction in the DW penalty from 50 to 25 bps on March 16, 2008 is indicated by the first vertical line. The date of the Lehman Brothers bankruptcy, September 15, 2008, is indicated by the second vertical line. Data sources are in Appendix Appendix A.2. The right panel figure shows the distribution of the percent of TAF auctions in which a bank bids above the DW rate. The X-axis values are calculated as 100*(number of TAF auctions where the bank bids above the DW rate)/(number of TAF auctions where the bank submitted a bid) for those banks which bid above the DW rate at least once. The median (25th percentile) vertical line indicates that half (25%) of the banks that submitted a bid above the DW rate did so in at least 67% (50%) of the auctions at which they participated.
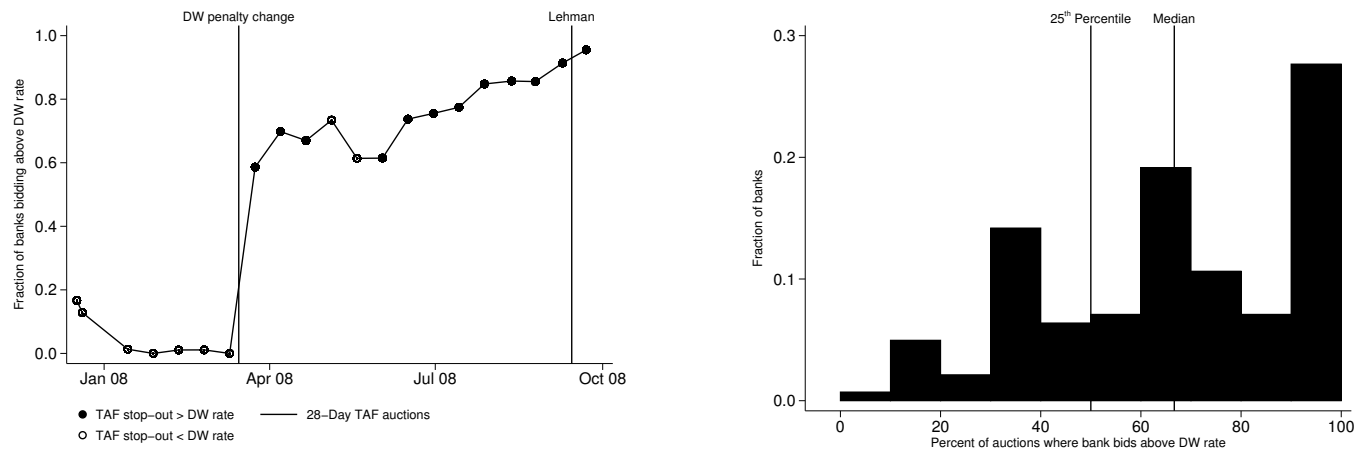
Figure 3:

Average realized DW stigma premium.
The figure illustrates the average realized DW stigma with respect to TAF, ABCP, and repo markets. For a bank that bids above the DW rate, the realized DW stigma premium with respect to TAF is the bank's highest TAF bid rate minus the DW rate. The realized DW stigma premium with respect to ABCP is the one-month ABCP rate minus the DW rate, conditional on the spread being positive. For collateral that is pledgeable for both repos and DW loans, the realized DW stigma premium with respect to repo is the repo rate minus the DW rate, conditional on the spread being positive. The reduction in the DW penalty from 50 to 25 bps on March 16, 2008 is indicated by the first vertical line. The date of the Lehman Brothers bankruptcy, September 15, 2008, is indicated by the second vertical line.
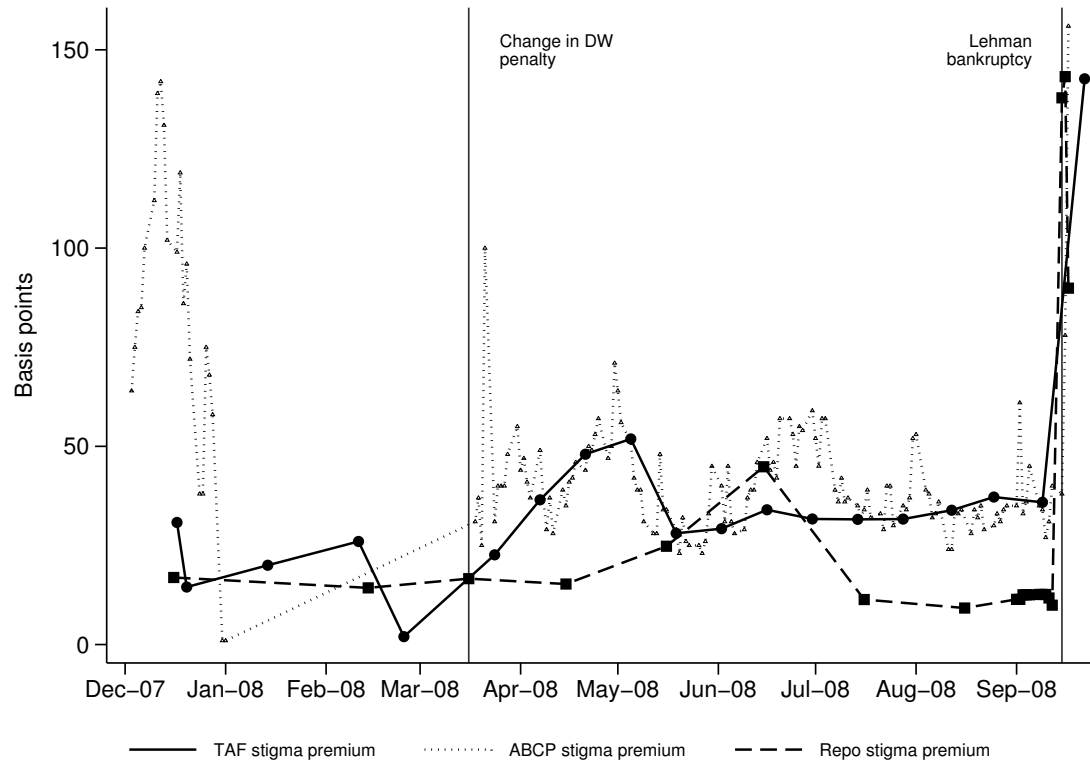
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