Stigma in Financial Markets

Evidence from liquidity auctions and discount window borrowing during the crisis*

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Abstract

We provide empirical evidence for the existence, magnitude, and economic impact of stigma associated with discount window liquidity provision by the Federal Reserve. We find that during the height of the financial crisis banks were willing to pay a premium of at least 37 basis points (150 basis points after Lehman's bankruptcy) on average to borrow from the Term Auction Facility (TAF) rather than from the discount window. The incidence of stigma varied with bank characteristics and market conditions. Finally, we find that discount window stigma is economically relevant since it increased banks' borrowing costs during the crisis. Our results have important implications for the provision of liquidity by central banks.

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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

An important role for central banks is to provide funding to solvent but illiquid banks either during times of system-wide liquidity shortages or when banks face idiosyncratic funding shocks. The Federal Reserve (henceforth Fed) employs the discount window (DW) for these tasks. Historically, however, there has been a low level of DW use by banks, even when they may have faced severe liquidity shortages. For example, at the onset of the financial crisis that emerged in 2007, few banks accessed the DW, despite the several policy measures enacted by the Fed to encourage borrowing from the DW.

There are potentially two explanations why banks did not visit the DW more often in the Fall of 2007. One explanation is that they avoided the DW due to a stigma associated with such borrowing, as Chairman Bernanke suggests in the quote cited above. An alternative explanation for the unwillingness to borrow from the DW is that banks could potentially borrow elsewhere at equal or cheaper rates. For instance, Armantier, Krieger, and McAndrews (2008) estimate that the interbank market rate was almost equal in the Fall of 2007, on average, to the expected DW rate. Moreover, Ashcraft, Bech, and Frame (2009) argue that at the onset of the financial crisis, the Federal Home Loan Bank system effectively acted as the Lender of Next-to-Last Resort, as it provided a less expensive source of funding than the DW. However, these potential explanations may be insufficient to account for the lack of DW borrowing after 2007.

In this paper, we examine whether banks avoided the DW due to stigma, where DW stigma is said to occur when a bank is willing to pay higher interest rates in order to avoid borrowing from the DW. Although such DW stigma has been discussed in the literature (e.g. Peristiani (1998)), in policy circles and anecdotally in the financial press, there is little empirical support for it.[1] Furfine (2003) provides empirical evidence regarding DW stigma based on

[1] For example, there was discussion of DW stigma in the financial press after some banks accessed the DW in August 2007. See *Deutsche Bank loan decision boosts Fed* (Financial Times, August 21, 2007) and *Big U.S. banks use discount window at Fed's behest* (The New York Times, August 23, 2007). Note also

borrowing in the federal funds market. However, as argued later, Furfine (2003)'s evidence is not directly relevant for the recent financial crisis and relies on a less precise methodology. The lack of empirical evidence about the magnitude of DW stigma creates policy uncertainty. Indeed, as argued by Chairman Bernanke in the quote cited above, the response of banks to a change in the DW rate becomes difficult to estimate, thus hampering the Fed's ability to provide liquidity. Moreover, stigma is also potentially costly for banks, to the extent that they turn to more expensive sources of financing during times of great liquidity needs.[2]

In addition to lacking formal empirical evidence, there is not a well established theoretical framework to study DW stigma. Only recently, some attempts were made at rationalizing DW stigma using signaling games. For instance, Ennis and Weinberg (2009) introduce a model in which a bank may be sending a negative signal about its financial health to financial market participants when it accesses the DW. This signaling game relies on two key assumptions. First, DW borrowing must be at least partially observable. In practice, the identities of DW borrowers are not made public. It appears well accepted, however, that market participants are often able to identify DW borrowers shortly after they access the DW. The second assumption is that accessing the DW sends a worse signal than borrowing on the market at a rate higher than the DW rate. Ennis and Weinberg (2009) show that DW borrowing may generate stigma on the asset market used by banks to finance themselves. In their model, participants in the asset market cannot observe borrowing rates on the interbank market but they can observe a bank taking a loan from the DW. A bank accessing the DW may then be interpreted by asset market participants as sending a negative signal about the quality of its assets. As a result, in equilibrium banks may prefer to pay more for loans in the interbank market in order to avoid borrowing from the DW.[3]

In this paper, we provide empirical evidence for the existence, magnitude, and economic

that, stigma has been more widely and extensively studied outside the realm of financial markets, such as unemployment, food stamps, and tax evasion. See for example, Iannaccone (1992), Moffitt (1983), Lindbeck, Nyberg, and Weibull (1999), Lui (1986), Rasmusen (1996), Vishwanath (1989), among others. For a view of stigma that is also applicable to financial markets, see Bikhchandani, Hirshleifer, and Welch (1992).

[2]In theory, for the DW to be effective, banks do not have to actually borrow from the facility as long as they believe that there is a credible commitment by the Fed to provide liquidity through the DW (see for example, Acharya, Gromb, and Yorulmazer (2010)).

[3]For a paper related to stigma with respect to government programs, see Philippon and Skreta (2010). Although not formalized in a theoretical model, it has been argued that DW stigma could exist not only with respect to financial markets, but also with respect to the Fed (see e.g. Furfine (2003)). By borrowing from the DW, banks may be concerned about sending a negative signal to the Fed which acts both as lender and a regulator. Except in the last section of the paper, we remain agnostic as to whether a bank's possible DW stigma is with respect to the Fed, or with respect to the other financial market participants.

impact of stigma associated with discount window liquidity provision by the Fed. Using a detailed and unique dataset, we compare banks borrowing behavior at the Fed's Term Auction Facility (TAF) and the DW. The TAF was a liquidity facility created by the Fed in December 2007 with virtually the same eligibility and collateral criteria as the DW. By lending term funds at market-determined rates using an auction mechanism, one of the Fed's objectives in designing the TAF was to eliminate the stigma concerns that were believed to have affected the DW.[4] Under mild assumptions, we show that a bank bidding at the TAF at a rate higher than the prevailing DW rate provides robust evidence of DW stigma. Using bid level data of TAF participation, we find that many banks submitted bids above the DW rate at TAF auctions throughout the crisis. In particular, banks consistently bid above the DW rate for a period of six months in 2008 (i.e. April to August 2008) when stop-out rates at the TAF (i.e. the equilibrium rates at which banks obtained TAF funds) were higher than at the DW. Therefore, bidding above the DW rate during this period implied that, with high probability, banks would pay more for TAF funds than the prevailing DW rate. 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 also find that banks' decision to bid above the DW rate at TAF auctions is affected by a number of bank-specific factors (e.g. the bank size and the amount of collateral pledged by the bank to the Fed), market risk factors (e.g. the overnight interbank spread and the volatility of interbank market rates), as well as central bank policy decisions (e.g. changes in the DW rate). These results therefore provide robust evidence of the existence of stigma and its determinants during the recent financial crisis.

Having established the existence of DW stigma, we then examine its magnitude. To do so, we define the DW stigma premium as the highest spread above the DW rate a bank would be willing to pay to avoid borrowing from the DW. Since willingness to pay is a latent variable, the DW stigma premium cannot be measured directly. To address this issue, we use the spread between the DW and a bank's TAF bid rates as a lower bound for that bank's DW stigma premium. During the period when the TAF stop-out rates were consistently higher than the DW rate, we find that banks were potentially willing to pay at least an additional 37 basis points, on average, at the TAF to avoid going to the DW. For banks that obtained TAF funding during this period, the actual additional cost was at least $ 5.5 million per

[4]For further institutional details on the TAF implementation, see Armantier, Krieger, and McAndrews (2008) as well as the FAQ on the Federal Reserve Bank of New York website `http://www.federalreserve.gov/monetarypolicy/taffaq.htm`.

auction and amounted to at least 5.6 % of their interest payments. Immediately after the bankruptcy of Lehman Brothers, the DW stigma premium rose to at least 150 basis points, implying an actual interest cost of at least $ 75 million per auction and at least 40 % of interest payments.

Having shown that banks borrowing behavior is affected by their beliefs about DW stigma, we study whether these beliefs can be rationalized. In particular, we examine whether or not a bank's interbank borrowing rates and stock prices are affected on days surrounding a DW visit. Although not consistently statistically significant, our results are consistent with the hypothesis that banks visiting the DW may face a moderate increase in borrowing costs and a moderate decrease in stock prices, relative to banks that do not visit the DW.

In the remainder of the paper, we describe in Section 2 the Fed's DW policy prior to and during the financial crisis, and the subsequent implementation of the TAF. In Section 3, we discuss the methodology for inferring the existence of DW stigma and provide supporting empirical evidence. In particular, we discuss why bidding above the prevailing DW rate at the TAF should be interpreted as evidence of stigma. In Section 4, we describe and estimate a probit model for examining the determinants of the probability that a bank bids for TAF funds at a rate higher than the prevailing DW rate. In Section 5, we provide estimates of the lower bound on the magnitude of stigma. In section 6, we study the economic importance of DW stigma by estimating banks' shadow cost of avoiding the DW and the changes in the borrowing costs and stock prices faced by banks visiting the DW. We provide concluding remarks in a final section.

2 The Supply of Liquidity by the Fed

In this section, we discuss how the Fed implements its lender of last resort function through DW operations, and provide a brief historical perspective of DW operations emphasizing the issue of stigma. The Fed introduced the TAF during the crisis to complement the DW as a borrowing facility. We subsequently discuss the design features of the TAF that were intended to remove the perception of stigma possibly attached to borrowing from the DW.

2.1 The Discount Window

An important role of a central bank is to serve as the Lender of Last Resort by providing discretionary liquidity when the private supply of liquidity is inadequate to meet the demand from the banking system (see, for example, Freixas, Giannini, Hoggarth, and Soussa (1999)). Normally, 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 U.S., the traditional way for the Federal Reserve Banks to provide emergency credit to depository institutions in their respective districts is through the DW.[6] DW lending is in the form of "advances," which are loans evidenced by promissory notes of the borrowing bank and secured by adequate collateral.

Like a private lender, the Fed is concerned with managing its credit risk by adjusting the interest rate on discount window loans and by stipulating a haircut on the collateral it receives.[7] Historically, the Fed has changed the list of approved collateral infrequently.[8] As

[5]The literature provides three reasons why central banks may be better providers of liquidity than the interbank market. First, the interbank market may be unable to distinguish solvent and insolvent banks, whereas a central bank may be better placed to do so because of the information it can gather through its supervisory role. For example, Berger, Davies, and Flannery (2000) find evidence that the Fed's assessment of a bank's future performance is better than that of the market shortly after Fed supervisors have inspected a bank. Second, Flannery (1996) argues that the central bank can provide sufficient liquidity to diversify risk across a large number of illiquid banks; in contrast, an individual bank's surplus may not be enough to lend to all illiquid banks. Rochet and Vives (2004) shows that if the interbank market loans contain a large adverse selection discount, as in Flannery (1996), then the central bank should supplement ex-ante regulation with DW loans at a very low rate. Third, Freixas, Giannini, Hoggarth, and Soussa (1999) point out that individual banks may hoard liquidity if they are concerned about losing access to funds in the future, whereas central banks have the ability to increase the money supply.

[6]The term "discount window" is a historical legacy from the times when much of the Fed's lending was done by discounting (in the early years of the Fed, banks mainly borrowed via discounts by presenting eligible bills and receiving credit from the Fed in an amount equal to the value of the asset at maturity minus a "discount"). All depository institutions that maintain transaction accounts or non-personal time deposits subject to reserve requirements are entitled to borrow at the discount window. These include commercial banks, thrift institutions, and U.S. branches and agencies of foreign banks. See `http://www.newyorkfed.org/aboutthefed/fedpoint/fed18.html` for details on the operations of the DW.

[7]The haircut is the amount by which the value of the collateral exceeds the value of the loan, expressed as a percent of loan value.

[8]In 1999, the Fed expanded the range of acceptable collateral to include investment-grade certificates of deposit and AAA-rated commercial mortgage-backed securities. Other acceptable collateral consists of U.S. Treasury securities, state and local government securities, collateralized mortgage obligations (AAA), consumer loans, commercial and agricultural loans, and certain mortgage notes on one-to-four family residences.

further discussed below, the Fed currently manages its exposure to credit risk by offering two different lending rates to banks depending on their credit worthiness.

2.2 Discount Window Lending and Stigma: Historical Perspective

The question of stigma has been a lingering issue throughout the history of the DW. According to Flannery (1996), the DW loan rate should be set below the break-even loan rate of a private lender who is unable to discriminate between a solvent and insolvent borrower. From the creation of the DW program and up until 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 "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 plausibly conclude that the bank had limited sources of funding. Therefore, setting rates below market created a perception of stigma associated with DW borrowing as it indicated financial weakness both to competitors and to the Fed. 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 in 2003.[9] In Regulation A, as revised in 2003, the Fed classified DW loans into primary credit, secondary credit and seasonal credit. Financially strong, well-capitalized banks can borrow under the primary credit program at a penalty rate (rather than a subsidized rate as in the past) above the target federal funds rate.[10] 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. Our focus in this paper will be on the primary credit facility.

For banks eligible for primary credit, the new DW is a "no questions asked" facility. Namely, the Fed no longer establishes a bank's possible sources of and needs for funding to lend money

[9]The policy change was announced on January 6, 2003 and was implemented on January 9, 2003 (see: `http://www.federalreserve.gov/boarddocs/press/monetary/2003/20030106/default.htm`).

[10]Reserve Banks determine eligibility for primary credit according to a uniform set of criteria, based mainly on the borrower's examination ratings and capital. Supplementary information, such as market-based information, also could be used to determine eligibility.

under the primary credit program. Instead, primary credit for overnight maturity ordinarily is allocated with minimal administrative burden on the borrower.

Despite these changes, DW borrowing remained sparse and perceptions of stigma resurfaced with the onset of the recent financial crisis. By the end of the summer of 2007, financial institutions were perceived to face serious liquidity shortages. To encourage borrowing, the Fed reduced the DW penalty (i.e. the spread over the target rate) from 100 basis points to 50 basis points on August 17, 2007 and agreed to provide DW financing for terms as long as 30 days.[11] In addition, the Fed issued statements that DW borrowing would be viewed as a sign of strength for banks.[12]

As indicated in Figure 1 which shows the average weekly DW primary credit outstanding in billions of dollars, these changes in policy generated little DW borrowing in 2007. Similar evidence is reported in Figure 2 which shows the average number of banks receiving DW loans each month. As it was perceived that the DW might not be sufficient to effectively supply liquidity to the banking system, the Fed introduced the TAF in December 2007. As further discussed in the next section, one of the primary objectives in designing the TAF was to eliminate any perception of stigma that may have been attached to borrowing from the DW.

2.3 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 purpose of the TAF was to serve as a complement to the DW by providing sound depository institutions with term funding at interest rates set competitively through an auction mechanism. Prior to each TAF auction, the Fed announced the amount of funds to be allocated. An eligible financial institution could then submit up to two bids, each consisting of a rate-quantity pair.[13] Bids were accepted in descending order of rates until the amount of funds supplied by the Fed was exhausted. The rate at which the total demand for term funding equals supply is the

[11] See `http://www.federalreserve.gov/newsevents/press/monetary/20070817a.htm`.

[12] See *Fed Cuts Discount Rate, Recognizing Need to Stem Credit Crisis* (Bloomberg August 18, 2007) `http://www.bloomberg.com/apps/news?pid=20601087&refer=home&sid=aE1A7RkmKsag` .

[13] TAF auctions had a minimum bid rate which was equal to the Overnight Index Swap (OIS) rate until January 12, 2009, and then to the rate of interest that banks earn on excess reserve balances (i.e. 25 basis points).

market clearing rate, known as the stop-out rate. The TAF belonged to the "uniform-price" (or single-price) class of auctions, whereby each bidder that submitted a bid at or above the stop-out rate was asked to pay the stop-out rate for the funds it received.[14] A total of 60 TAF auctions were conducted roughly every two weeks between December 17, 2007 and March 8, 2010 when the TAF program was terminated. The amount allocated at TAF auctions varied from $ 20 billion initially to $ 150 billion at the peak of the crisis. The terms of the funds allocated were either 28 or 84 days, with a few exceptions.

Since the TAF was introduced as a complement to the DW, the two facilities shared a number of important features. As indicated in Table 1, where the two facilities are compared and contrasted, funding was offered against the same collateral and using identical haircut calculations for 28-day funds. In addition, during the period studied in this paper, the same institutions, namely those deemed in sound financial condition by their Federal Reserve District Reserve Bank, had access to both facilities. Finally, the identities of borrowers were not disclosed by the Fed at either facility.

The TAF and the DW facilities are also different in some respects. First, the borrowing rate at the TAF was set through competitive bidding at an auction, while the DW offers a posted rate determined by the Fed. Second, while most TAF auctions allocated funds for either 28 or 84 days, DW loans could be obtained for any term from overnight to 90 days.[15] Third, TAF loans could not be prepaid, while DW loans can be repaid at any time. Fourth, TAF bidding by an individual participant was limited to 10 % of the total amount offered at the auction.[16] Fifth, whereas DW loans are credited on the same day, TAF awards were only credited to the winning bidders three days after the auction. Last but not least, the DW facility is available every business day, whereas the TAF was typically operated only at two-week intervals.

[14]Bids submitted above the stop-out rate were fully funded, while bids submitted at the stop-out rate were prorated based on the amount tendered.

[15]The DW offered only overnight loans until August 17, 2007, after which the terms were extended to 30 days. On March 17, 2008 the terms of the DW loans were once again extended to 90 days. Primary credit terms were reduced to 28 days on January 14, 2010, and returned to the historical overnight term on March 18, 2010. Since its inception, the TAF has typically offered funds for a term of 28 days. Longer term loans (typically 84 days) have also been auctioned at the TAF between August 11, 2008 and November 30, 2009.

[16]The TAF also had a minimum bid amount requirement. The minimum amount was initially set at $ 10 million, and then rapidly reduced to $ 5 million on February 1, 2008. There is no minimum requirement at the DW, but in practice, this difference can be considered minor. Few banks take loans at the DW for amounts less than the TAF minimum. In addition, banks that lacked the collateral to make the minimum TAF bid generally had sufficiently large balance sheets to allow them to post more collateral if needed.

Observe that some features of the TAF facility were purposely introduced by the Fed to remove the concern of stigma that was attached to the DW. Indeed, 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 need for funding.[17] In addition, a fully subscribed TAF auction would have at least 10 winners (given the 10% cap on bid size) which further reduced the likelihood of an individual participant being identified. In contrast to the DW, the TAF may be considered an immediate success in terms of number of participants, amounts bid and amounts allocated (see Figures 1 and 2), thereby supporting the hypothesis that, indeed, banks initially attached no stigma to TAF bidding.

3 Is There Discount Window Stigma?

We explained in the previous section that, when it was created, the TAF was a close substitute for the DW from the perspective of a bank. Where differences exist between the two facilities, the effect of these differences is to make the DW a more flexible borrowing mechanism for banks (note, in particular, the possibility of early repayment of DW loans). In addition, there is no evidence that a perception of stigma was initially attached to the TAF, whereas the DW carries a historical legacy of stigma. It therefore follows that, in the absence of DW stigma, a bank should have no reason to favor TAF borrowing over DW loans when both loans are available at the same rate. This observation constitutes the basis for our methodology which involves comparing banks' TAF bids with the prevailing DW rate. In a first subsection, we describe our methodology to test the existence of stigma associated with DW borrowing. The second subsection describes the results from these tests.

3.1 Testing for the Presence of DW Stigma

Consider a bank on the day (typically Monday) of a 28-day TAF auction. Imagine the bank wishes to borrow funds from the Fed for a term of 28 days starting on the following Thursday (the TAF settlement day). The bank then faces an alternative. It can either place a bid at

[17]For further institutional details on how the TAF was designed to remove DW stigma, see Armantier, Krieger, and McAndrews (2008).

the TAF or decide to access the DW on the TAF settlement day. Observe that, if rational, the bank should not access the DW without first attempting to get the funds from the TAF at a more favorable rate. Indeed, the option to turn to the DW on Thursday is still available to the bank, if it learns on Wednesday (i.e. the day that TAF auction results are reported to the public) that its TAF bid was rejected.[18]

We further argue that in the absence of DW stigma, the bank should place a TAF bid at a rate at or below the DW rate.[19] To rationalize this argument, we make the mild assumption that each bank has a maximum willingness to pay (MWTP) for funds from the Fed. The MWTP is therefore equal to the rate above which a bank would not borrow any funds from the Fed.[20] The MWTP may differ across banks depending on their respective funding needs and on the rates at which they can borrow in the market. We can then show that it is a dominated strategy for a bank to bid above its MWTP, that is, a bank has nothing to gain in bidding above its MWTP.[21]

To see this, consider Figure 3 where we illustrate the three outcomes that are possible when a bank bids above its MWTP, depending on the stop-out rate of the auction. First, if the stop-out rate is above the bid of the bank (outcome 1 in Figure 3), then the bank's bid is rejected, just like it would have been rejected if the bank had bid its MWTP. Second, if the stop-out rate is below the MWTP of the bank (outcome 2 in Figure 3), then the bank does equally well as whether it bids at or above its MWTP, since the gains accruing to the bank are the same in either situation. Finally, if the stop-out rate is higher than the MWTP but lower than the bid of the bank (outcome 3 in Figure 3), then the price paid by the bank (the stop-out rate) is above its MWTP. The bank incurs the losses indicated in Figure 3 and therefore, it would have been strictly better off bidding its MWTP.

In summary, in the absence of DW stigma, a TAF participant cannot do better by bidding

[18]We are not implying that a bank should only borrow from either the TAF or the DW. A bank could rationally borrow funds at both facilities (e.g. if it needs funds on a day TAF auctions are not conducted).

[19]In fact, given the added flexibility of the DW (most importantly, the prepayment option), one could argue that, absent DW stigma, a bidder should submit a TAF bid strictly below the DW rate.

[20]We are not trying to derive a formal game theoretic auction model as in, for example, Wilson (1979). Therefore, the MWTP should not be interpreted as a bidder's private demand function for funds from the Fed. We only impose enough structure to show that, absent DW stigma, a bank should not bid above the DW rate. In more formal share auction models with a uniform price mechanism similar to the one used for the TAF, it is well known that bidders shade their bids (see, for example, Ausubel and Cramton (2002)). Therefore, we will not assume that banks bid exactly their MWTP.

[21]The rationale is similar to showing that bidding above one's value is a dominated strategy at a second price (single unit) auction.

above its MWTP.[22] Then, two situations should be distinguished depending on the position of a bank's MWTP relative to the DW rate. First, when a bank's MWTP is at or below the DW rate, the bank may try to get funds from the TAF by bidding below its MWTP. If this attempt fails, however, the bank will not turn to the DW as the DW rate is above what the bank if willing to pay for funds from the Fed. Second, absent DW stigma, the DW becomes a viable option as soon as a bank has a MWTP for funds from the Fed that is above the DW rate. In that case, if the bank fails to get the funds from the TAF it will turn to the DW. Since the DW is the bidder's outside option in this case, a bidder will not only bid below its MWTP, but it should also bid no higher than the DW rate. This result forms the basis of our empirical methodology: absent DW stigma, a rational bank should never bid above the DW rate. We will therefore interpret a bid above the DW rate as evidence of stigma.

Note that the methodology just presented relies on the assumptions that the TAF and DW are close substitutes, and that no stigma is attached to the TAF.[23] Accordingly, our analysis will focus exclusively on the first 21 TAF auctions for 28-days funding conducted between December 17, 2007 and September 22, 2008. We concentrate on this period for three reasons. First, after the amounts allocated at the TAF were increased from $75 to $150 billion on October 6, 2008, none of the subsequent TAF auctions were fully subscribed. As a result, the stop-out rate was not determined competitively and settled at the minimum bid rate. In this context, it may be argued that the information content of the rates bid at these auctions was meaningless, since TAF participants could expect with high probability that their bids would not affect the auction stop-out rate. Second, soon after the Troubled Assets Relief Program (TARP) was introduced in October 2008, discussions of stigma associated with government programs started to surface.[24] As a result, although the initial popularity of the TAF does support the hypothesis of no TAF stigma, we cannot exclude the possibility that later on some banks refused to participate at the TAF out of concern they would be stigmatized. Third, with the heightened uncertainty that followed the collapse of Lehman

[22] A bidder could rationally bid above its MWTP only if it believes that outcome 3 occurs with zero probability. After September 2008, every TAF auction was under-subscribed and therefore settled at the minimum bid rate. It may therefore be argued that TAF participants did place zero probability on outcome 3 in these auctions. As further discussed below, this is one of the reasons why our sample only includes fully subscribed auctions.

[23] If in fact there was TAF stigma, then our results should simply be reinterpreted as a study of relative DW stigma, that is, the DW stigma relative to TAF stigma.

[24] The article entitled *An offer US banks could not refuse* (Financial Times, May 15, 2009) describes how the original TARP distribution was structured to minimize stigma and *Repaying TARP* (Financial Times, May 18, 2009) discusses how it failed to avoid creating a stigma.

Brothers, district Federal Reserve Banks may have restricted some depositary institutions in their ability to borrow funds at the DW and/or at the TAF for maturities longer than overnight. As a result, for the purposes of this paper, the DW and the TAF may only be considered close substitutes before October 2008.

An alternative methodology for estimating the incidence of DW stigma has been proposed by Furfine (2003) who tests empirically whether DW stigma persisted in the months that followed the 2003 changes in DW policies. Furfine (2003)'s empirical approach essentially consists in comparing the DW rate with the rates at which banks transact fed funds on the market. He argues that if banks borrow fed funds for overnight maturity at a rate above the DW rate, then this may be interpreted as evidence of DW stigma. Using a sample covering a period of 3 months after the January 9, 2003 implementation of the new DW policy, Furfine (2003) finds evidence of DW stigma. In addition to the fact that Furfine (2003)'s data may not span a period long enough to allow banks time to adjust to the new DW rules, we see two potential problems with Furfine (2003)'s empirical approach.

First, the fed funds market and the DW cannot be compared directly as they are not perfect substitutes. In particular, while borrowing from the DW requires collateral, the fed funds market is uncollateralized and lenders may ask for higher rates to cover the added risk. Second, fed funds transactions are not observed directly. Instead, they need to be inferred using an algorithm. This algorithm uses data from Fedwire, the real-time gross settlement system operated by the Fed where most fed funds transactions are settled. In essence, the inference problem resides in identifying which of the Fedwire transactions are actually fed funds trades. To do so, Furfine (2003) devised an algorithm which, despite its appeal, may generate noise by keeping transactions that are not fed funds trades and by discarding actual fed funds trades. In fact, attempts to validate the accuracy of the algorithm have not been successful to this point.

3.2 Empirical Evidence on the Existence of DW Stigma

The sample consists of the 178 banks that participated in at least one of the 21 fully subscribed TAF auctions for 28-days funds conducted between December 17, 2007 and September 22, 2008. Therefore, banks that were eligible to bid but chose not to do so are not included in the population we consider. We plot in Figure 4 the fraction of banks participating at a TAF auction that bid above the prevailing DW rate. We find that 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. Between March and October 2008, the fraction of banks bidding above the DW rate was large (more than 55 percent) with a generally increasing trend. The first row of Table 2 shows that, of $1,540$ bank-auction pairs in the sample, bids above the DW rate occurred 56 percent of the time on average. We interpret this result as conclusive evidence of DW stigma during the 2007-2008 crisis period.

A possible objection to our reasoning is that, in the absence of DW stigma, some banks could use a weakly dominated strategy consisting in bidding above the DW rate if the expected cost of doing so is zero. Such a situation might occur if, with high probability, banks expect the stop-out rate to be below the DW rate. Figure 4 provides evidence to refute this argument. Indeed, after the reduction in the DW penalty rate on March 16, 2008, twelve of the subsequent fourteen TAF auctions (indicated by solid circles in Figure 4) settled above the DW rate. In other words, borrowing funds from the Fed was actually less expensive at the DW than at the TAF for a sustained period of time in 2008 (nearly 6 months). Therefore, banks making high bids at the TAF during this period faced a high probability that their actual borrowing rate would exceed the DW rate.

Moreover, it does not appear that bids above the DW rate could be explained by several banks making occasional bidding mistakes. Figure 5 describes the distribution of the percent of auctions in which a bank bids above the DW primary credit rate. It shows that some banks tend to repeatedly bid above the DW rate. In particular, the median vertical line in Figure 5 shows that 50 % of banks that submitted a bid above the DW rate did so at 2/3 or more of the TAF auctions at which they participated.[25] Although not reported in the figure, we further find that 38 out of the 178 TAF participants in our sample submitted bids above the DW rate at every auction at which they participated.

Figure 4 clearly exhibits two different regimes. Prior to March 16, 2008, when the Fed reduced the DW penalty rate, bidding above the DW rate was rare. After this date, bidding above the DW rate became frequent. Under the assumptions made in the previous section, this regime shift may be explained by a simple mechanical effect, as illustrated in Figure 6 (first plot on the left labeled "Scenario 1"). Lowering the DW penalty makes borrowing from the DW more affordable, but may not substantially affect a bank's MWTP for funds from the Fed as the DW penalty rate is unlikely to have a direct impact on private credit markets. Under the assumption that the MWTP remains unchanged, some banks who had

[25] On average, this group of banks participated at more than 8 of the 21 auctions in our sample.

previously considered the DW too expensive might now find it a more affordable option once the DW penalty rate has been reduced. For instance, we can see in Figure 6 (Scenario 1) that a bank's MWTP was initially below the prevailing DW rate, but then became higher than the DW rate are after the reduction in the penalty rate. As more banks are now willing to pay more than the DW rate, they should also become more likely to submit bids above the new DW rate.

In summary, we find that, during our sample period, bidding at the TAF above the prevailing DW rate was frequent and 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 crisis period of 2007 to 2008.

4 Determinants of the incidence of DW Stigma

Having documented that some banks exhibit DW stigma, we now attempt to identify the factors that may influence the incidence of DW stigma. To do so, we estimate a probit model with bank specific random effects. In a first subsection, we discuss the model specification, while in the second we report the empirical results.

4.1 Model Specification

We estimate a probit model with a bank specific random effect (ν_i) where the dependent variable y_{it} equals 1 when bank i submits a bid above the DW rate at TAF auction t, and zero otherwise. We first estimate a baseline model of the form:

$$\begin{aligned} y_{it} \;=\; & \alpha_0 + \alpha_1 \text{Log of assets}_{it} + \alpha_2 \text{Log of pledged collateral}_{it} \\ & + \alpha_3 \text{Pledged collateral increased}_{it} \\ & + \alpha_4 \text{Bank bid at previous auction}_{it} + \alpha_5 \text{Awarded funds at previous auction}_{it} \\ & + \alpha_6 \text{Bid above DW at previous auction}_{it} \\ & + \alpha_7 \text{Fed funds standard deviation}_t + \alpha_8 \text{LIBOR-OIS spread}_t + \nu_i + \varepsilon_{it} \end{aligned} \tag{4.1}$$

The baseline specification includes three groups of variables pertaining to (a) individual bank

characteristics, (b) auction related variables and (c) proxies for market funding conditions.[26] The bank i characteristics at auction t include a measure of the bank size (*Log of assets*), the amount of collateral the bank pledged at the DW (*Log of pledged collateral*), and a dummy equal to 1 when the bank increases its pledged collateral from the previous auction (*Pledged collateral increased*). The baseline model controls for the latter two variables as they may indicate a bank's intent to bid aggressively at the auction. Indeed, by bidding aggressively a bank increases its chances of obtaining funding at the TAF which would then require collateral. The sign of α_1 indicates whether bigger banks bid more or less aggressively than smaller banks. Positive values of α_2 and α_3 imply that banks with more collateral pledged at the DW, and banks that increased the amount of collateral they pledged from the previous TAF auction are more likely to bid above the DW rate.

Since banks' behavior may be persistent, we include variables related to a banks' bid and award at the previous auction. The coefficients α_4 through α_6 indicate whether a banks' past bidding behavior increases or decreases the incidence of DW stigma. A positive sign on α_6 implies that a banks' incidence of stigma is persistent. Likewise, a positive value of α_4 implies that returning TAF bidders are more likely to experience stigma. Recall that 28 day TAF auctions were conducted roughly every two weeks which implies that TAF loans overlap. As a result, we might expect that α_5 may be negative as funding in the previous auction may decrease the need for additional funding, and hence decrease the probability of bidding above the DW rate.

Finally, the last two parameters measure how market conditions affect the incidence of DW stigma. Following Vives (2010), we expect α_7 and α_8 to be positive. Indeed, Vives (2010) shows that an increase in stress indicators such as the LIBOR-OIS spread raises the probability of a crisis and increases the impact of bad news, such as possibly a DW visit that becomes public. This is because public news has a multiplier effect on asset prices beyond its informational content as each agent anticipates the reaction to bad news of other agents and so everyone becomes more cautious in acting.

Since interest rate policy changes may affect market rates, we also re-estimate the baseline model after adding two variables controlling for (1) the March 16, 2008 reduction in DW penalty rate, and (2) changes in the Fed's target rate. These variables are: *After DW rate change*, which equals 1 after March 16, 2008, and is zero otherwise, and *Fed funds target rate*, which is the level of the fed funds target.

[26]The exact definitions of the variables are given in the Appendix.

In our final specification, we further account for banks' recent DW activity. The objective is to examine whether the incidence of DW stigma depends on how frequently banks use the DW as a source of funding, both individually and collectively. Thus, we include the following variables in the regression. *Days in last week bank took DW loan* is the number of days during which a bank had an outstanding DW loan in the week prior to the TAF auction. *Banks taking DW loans week before* refers to the total number of banks that received DW loans in the week prior to the TAF auction.

4.2 Empirical Results

Results from estimating the baseline model are reported in column 1 of Table 3. In terms of individual characteristics, it appears that the incidence of stigma is more frequent among smaller banks (i.e. banks with fewer assets) since the estimated value of α_1 is negative and significant. This result may imply that smaller banks have a higher DW stigma. Alternatively, it may simply reflect the fact that during the crisis small banks had a higher MWTP for funds from the Fed, as they may have found it more difficult than their larger counterparts to fund themselves on the market. Once we control for size, we find that banks with more collateral pledged at the DW and banks that increased the amount of collateral they pledged from the previous TAF auction are more likely to bid above the DW rate.[27] These results are consistent with the hypothesis that, as they intend to bid aggressively, these banks anticipate they will receive funds at the TAF auction, and therefore plan to have the necessary collateral pledged at the Fed.

Considering a bank's past bidding behavior, the regression results suggest that first time and non-returning TAF bidders are more likely to exhibit DW stigma. Since the estimated value of α_4 is negative and significant, the probability of bidding above the DW rate is lower when a bank participated at the previous the TAF auction. In contrast, the incidence of DW stigma is not significantly affected by whether or not banks were awarded funds at the previous the TAF auction. Moreover, consistent with our prior result that the incidence of DW stigma is persistent (see Figure 5), the magnitude of α_6 in Table 3 suggests that a bank is 65 % more likely to bid above the DW rate if it also did so at the previous auction.

[27] Although, the two variables *"log of assets"* and *"log of pledged collateral"* are relatively highly correlated ($\rho = 0.622$), the estimated parameters do not change significantly when one of the two variables is excluded. Therefore, it appears that each captures different information about TAF bidding and they do not seem to create a multicollinearity problem.

Market conditions significantly affect the incidence of DW stigma. The coefficients on the volatility of fed funds rates (α_7) and the LIBOR-OIS spread (α_8) are found to be positive and significant. Consistent with Vives (2010), the incidence of DW stigma appears more frequent when there is greater uncertainty about the rates at which banks can obtain funds in the private market and when the market risk premium is high.

The impact of policy changes on the incidence of DW stigma is reported in column 2 of Table 3. We find that, consistent with Figure 4, more banks were likely to bid above the DW rate after the DW penalty rate was reduced on March 16, 2008. This may be due to the mechanical effect of decreasing the penalty rate on stigma, as discussed earlier (see also Figure 6). In addition, we find that the parameter associated with the target rate is positive and significant, thereby indicating a decrease in the incidence of DW stigma when the Fed lowers the target rate. Interpreting this result is subtle, as changes in the target rate may produce two opposite effects. First, it produces an equal reduction in the DW primary rate; second, it should lower a bank's MWTP as a reduction in the target rate is generally expected to ease market conditions. As illustrated in Figure 6, the impact of a change in the target rate on the incidence of DW stigma depends on the relative magnitude of these two effects. In the middle plot labeled "Scenario 2a" in Figure 6, the bank experiences a relatively modest reduction in its MWTP. As a result, the position of the bank's MWTP with respect to the prevailing DW rate changes: the MWTP was initially below the DW rate and then becomes higher than the DW rate. The incidence of DW stigma for the bank is therefore likely to increase after the target rate has been reduced. In contrast, the bank experiences a relatively large reduction in its MWTP in the right plot labeled "Scenario 2b" in Figure 6. As a result, the bank moves from a position in which it could conceivably bid above the DW rate, to a position in which it will not bid above the DW rate. Lowering the target rate therefore reduces the incidence of DW stigma for that bank.[28] The results of the probit model suggest that the effect in the second scenario dominates.

We next estimate the effects of banks' recent DW activity on the incidence of stigma. As indicated in column 3 of Table 3, all else equal, more DW visits by a bank in the previous week makes it less likely that the bank bids above the DW rate at the TAF. Such behavior suggests that, in the short term, the incidence of DW stigma declines with the number of recent DW visits. Our estimation results also suggest that an increase in the number

[28]Note that Scenario 2b does not require the new MWTP to become lower than the prevailing DW rate. The incidence of stigma could still decrease even when the new MWTP remains slightly higher than the prevailing DW rate, as long as the relative reduction in MWTP is sufficiently large.

of banks taking out DW loans is associated with a higher incidence of DW stigma. One possible explanation for this counterintuitive result is that, an increase in the number of banks visiting the DW may reflect a worsening in market conditions not captured by the covariates in our econometric model.

To conclude this section, we observe that results from estimating various specifications of the econometric model reported in Table 3 attest to the robustness of our conclusions. Indeed, both the significance and the magnitude of most of the estimated parameters remain very similar regardless of the specification.

5 The Magnitude of the DW Stigma Premium

The economic relevance of DW stigma depends on its magnitude. Having shown the existence of DW stigma, we now estimate a lower bound for the magnitude of the DW stigma and analyze the determinants of this lower bound. In the first subsection, we discuss methodological issues related to estimating the magnitude of DW stigma. In the second subsection, we report estimates of lower bounds on the DW stigma premium and the variation of these bounds during the crisis period.

5.1 Methodology

We define the "DW stigma rate" as the highest interest rate a financial institution is willing to pay in order to avoid borrowing at the DW. By extension, we define the "DW stigma premium" as the difference between the DW stigma rate and the DW rate. As illustrated in Figure 7, we only define these variables when a bank exhibits DW stigma, that is, when the DW stigma premium is positive.

Observe first that we make a distinction between the DW stigma rate and what we previously referred to as a bank's MWTP to borrow funds from the Fed. The former may be interpreted as a bank's true cost of borrowing at the DW, while the latter reflects the bank outside option (e.g. the rates it can obtain on the market). Prior to the implementation of the TAF program, a bank would therefore only access the DW when its MWTP would exceed its DW stigma rate. Note also that we do not impose any restrictions on the determinants of the DW stigma rate. It may vary across financial institutions (depending, for example, on

bank specific needs and financial health) and over time (depending, for example, on general economic conditions).

As defined, the DW stigma rate (and by extension the DW stigma premium) is a latent variable. Proxies for the DW stigma rate, such as rates paid on the market, bids at the TAF, and borrowing at the DW, can only provide a lower bound on the DW stigma rate. For instance, a financial institution paying x % above the DW rate on the market may have been willing to pay even more to avoid borrowing from the DW. Likewise, 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).[29] As a result, we can only hope to approximate the DW stigma rate and premium from below.

The lower bound we adopt for a bank's DW stigma rate is its TAF bid on the day of a TAF auction. More specifically, as illustrated in the left plot labeled "Scenario 1" of Figure 7, we calculate what we call the "realized DW stigma premium" as the difference between a bank's highest bid rate at a TAF auction and the DW rate. Note in Scenario 1 of Figure 7, that this variable is only defined when there is actual evidence of DW stigma, that is, when a bank bids above the DW rate. In other words, the realized DW stigma premium is only defined when it is strictly positive.

As defined, the realized DW stigma premium may therefore be considered a legitimate lower bound for the DW stigma premium. This approach, however, has limitations. In particular, although we may be able to identify the determinants of the realized DW stigma premium, those same determinants may not automatically extend to the (unobserved) DW stigma premium. As illustrated again in Scenario 1 of Figure 7 the MWTP, the TAF bids, and therefore the realized DW stigma premium, could vary (for example, across banks or over time) while the DW stigma rate could remain unchanged. In other words, the DW stigma premium and its lower bound could vary independently of each other.

5.2 Empirical Results

We plot in Figure 8 the realized DW stigma premium averaged over all banks bidding at a TAF auction. 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,

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

it remained virtually unchanged around 37 basis points during the eight auctions conducted in summer 2008, a period during which TAF funding was more expensive than the DW rate.

We further observe in Figure 8 that the average realized DW stigma premium suddenly jumps from around 37 to 143 basis points after Lehman Brothers filed for bankruptcy. To understand this result, recall that at the time, there was intense speculation about the identity of the next bank that might fail. In those times of heightened tension and scrutiny, it therefore appears natural that banks were willing to go to greater expense in order to avoid showing any signs of weakness. In particular, our results suggest that banks were willing to pay a substantial premium in order to avoid borrowing from the DW which, if detected, might have been interpreted as a sign of financial trouble.

In contrast to Figure 4, we do not see any evidence of a structural break after the March 16, 2008 reduction in the DW penalty rate. Earlier, we found that the policy change increased the incidence of DW stigma, as an expanded set of banks bid for TAF funds at a rate higher than the DW rate. The expected impact of the policy change on the average realized DW stigma premium is, however, ambiguous. To illustrate this point, consider Figure 7 were we compare two scenarios before (Scenario 1) and after (Scenario 2) a reduction in the DW penalty rate. On the one hand, the group of banks which already experienced DW stigma before the policy change now has a larger realized DW stigma premium. On the other hand, there is a new group of banks which had not previously experienced DW stigma, with now low realized DW stigma premium (e.g. see the bank with $MWTP_1$ and $TAFBid_1$). The combination of these two effects is ambiguous and no clear prediction can be made about how a reduction of the DW penalty rate impacts the average realized DW stigma.

To better understand the determinants of the realized DW stigma premium, we regress a bank's realized DW stigma premium at an auction on a number of explanatory variables, including a bank specific random effect. The set of explanatory variables is identical to those used in Table 3. The results of the baseline model reported in Table 4 reveal that several bank characteristics have significant power to explain a bank's realized DW stigma premium. In particular, we find that small banks are not only more likely to experience DW stigma (see Table 3), but they also appear to have a larger realized DW stigma. More precisely, our results suggest that a 1 % increase in assets is associated with a 5.25 basis points reduction in the realized DW stigma premium. Once we control for size, we find a higher realized DW stigma premium for banks with large amounts of collateral pledged at the DW, and banks that post additional collateral compared to the previous TAF auction. Consistent with

earlier conclusions, these results may reflect the idea that banks that bid more aggressively are more likely to be awarded funds, and therefore plan to have the necessary collateral pledged at the Fed.

The outcomes of the baseline model also suggest that a bank's realized DW stigma premium is correlated with its past bidding behavior at the TAF. In particular, it appears that banks that bid above the DW rate at the previous auction have a larger realized DW stigma premium. As we shall see, however, the magnitude and significance of this effect decline once we control for market conditions and recent DW activity. According with intuition, we also find that the magnitude of the realized DW stigma premium is positively correlated with the market risk premium, as measured by the LIBOR-OIS spread. The market variables, however, are not sufficient to fully explain the sharp increase in realized DW stigma observed after the bankruptcy of Lehman Brothers. Indeed, a dummy variable controlling for this event is estimated to be highly significant and substantial in magnitude (more than 100 basis points). In other words, our results suggest that the banks' bidding behavior following the failure of Lehman Brothers is not fully explained by deteriorations in our proxies for market conditions at the time.

Next, we augment the baseline model by controlling for policy variables (column 2 in Table 4). Consistent with Figure 8, we find that the March 16, 2008 change in the DW penalty rate did not have a significant effect on the realized DW stigma premium. In contrast, our results suggest that the realized DW stigma premium increased slightly as the Fed lowered its target rate during the crisis. Finally, the results reported in column 3 of Table 4 suggest that the number of visits by a bank to the DW in the week prior to a TAF auction reduces that bank's realized DW stigma premium. The nature of this result is similar to that in Table 3 where we found that the incidence of stigma decreased for banks with more frequent recent DW visits. We also find that, all else equal, the realized DW stigma premium is positively correlated with the number of banks taking DW loans the week prior to a TAF auction. Although possibly surprising, this result may reflect the fact that the number of banks visiting the DW may increase when market conditions deteriorate and this effect is not captured by our proxies, as previously discussed.

6 The Economic Cost and Market Impact of DW Stigma

The economic relevance of DW stigma may also be gauged by evaluating the banks' shadow costs of avoiding the DW. In the first subsection, we estimate the dollar amount banks potentially could have saved by borrowing at the DW instead of bidding at the TAF. In the second subsection, we attempt to rationalize the beliefs banks hold about DW stigma by examining the reaction of markets after a bank accesses DW.

6.1 Shadow Cost of DW Stigma

To evaluate how much it costs for banks to borrow at the TAF instead of at the DW, we first conduct a counterfactual exercise for each bank that bids above the DW rate at a given TAF auction, by considering a situation in which the bank would pay its own bid. In other words, we assume that the bank is the auction's marginal bidder that sets the auction's stop-out rate. We then subtract the DW rate from the bank's TAF bid rate and multiply the difference by the amount of funds bid by the bank. Since the bank under consideration bid above the DW rate, the resulting amount represents how much more a bank risked paying to meet its funding need at the TAF instead of taking the loan at the DW. As a result, the measure obtained may be interpreted as the potential cost of DW stigma.

The results of the exercise are reported in Table 5 Panel A. They indicate that the total potential cost for all banks was around $ 18 million per auction on average for the full sample, or equivalently $ 0.43 million per auction for each bank that experienced DW stigma. When expressed in relative terms, the potential cost for the full sample represented roughly 12 % of the potential interest payments (i.e. the amount the bank would have been charged if awarded the bid amount at its bid rate). During the summer of 2008, when funding at the TAF was consistently more expensive than at the DW, the potential cost was almost $ 16 million per auction, or $ 0.26 million per bank per auction, and more than 12 % of the potential interest payments. All of these measures increased greatly after the bankruptcy of Lehman Brothers. Indeed, the potential cost per bank per auction rose sharply to $ 2.05 million dollars after the Lehman bankruptcy, which, when expressed in relative terms, corresponds to nearly half of the banks' potential interest payments.

In addition to the potential cost of DW stigma, we also calculate the realized cost by considering exclusively the 12 TAF auctions that settled above the DW rate. For each of these auctions, we calculate the difference between the auction's stop-out rate and the DW rate and multiply the difference by the amount of funds actually awarded to the banks. This number represents how much more each bank that received funds actually paid at the TAF instead of going to the DW. According with intuition, we find in Table 5 Panel B that the total realized cost relative to DW stigma is smaller than the potential cost during the full sample and each subsample. For example, during the summer of 2008, the realized cost is nearly 3 times smaller than the potential cost ($ 5.5 million per auction compared to a potential cost of $ 15.9 million per auction). The average realized cost per bank per auction is also smaller than the potential cost, except for the auction that followed the failure of Lehman Brothers. There, the average potential cost per bank was $ 2.05 million while the realized cost was $ 2.41 million. The realized cost was higher in this situation because the TAF stop-out rate was sufficiently higher than the DW rate that some banks did not receive funds despite bidding above the DW rate. The realized costs appear to represent an economically significant amount for banks. For example, during the full sample, the realized cost represented about 9.1 % of banks' actual interest payments. We conclude that banks could have paid substantially lower interest payments if, instead of borrowing funds at the TAF, they had borrowed those same funds from the DW.

6.2 The Impact of DW Visits on Asset Prices

The analysis above indicates that banks perceive DW stigma to exist when making their TAF bidding decisions. A natural question is therefore whether or not the beliefs of these banks may be rationalized. In other words, do banks indeed incur losses after visiting the DW that would justify paying higher rates to avoid borrowing at the DW in the first place? From a theoretical perspective, Ennis and Weinberg (2009) argue that a bank's DW visit may be interpreted by asset markets participants as sending a negative signal about the quality of its assets which, in turn, could negatively impact the prices of these assets. Likewise, in the model of Philippon and Skreta (2010) banks have an incentive to opt out of government programs to signal that their assets are of good quality and thereby obtain lower rates in financial markets.

To test empirically whether banks incur losses after accessing the DW, we estimate the impact

of banks' DW visits on (1) their stock prices, and (2) their overnight interbank borrowing rates. Although the equity market is not a funding market, DW visits may nevertheless impact stock prices if these visits prompt investors to reassess the quality of banks' balance sheet.

In estimating the impact of DW visits on asset prices, the timing of DW visits determines when such an impact may be observed (if at all). During the pre-crisis period, overnight DW loans were extended late in the day. With the availability of term loans during the crisis, however, banks requested DW loans throughout the day. Regarding fed funds borrowing, Bartolini, Gudell, Hilton, and Schwarz (2005) find no strong intraday pattern. Likewise, equity trading activity occurs throughout the day. These observations suggest that we might expect to observe an effect of DW visits on the same day and, perhaps, the days following the visit. To the extent that a bank's DW visit may be anticipated (e.g. as a result of a negative and publically observable shock incurred by the bank), we might also observe an effect on the days prior to, and possibly on the same day the bank visits the DW. For instance, a bank could be led to the DW late in the day because of its inability to meet its funding needs that day due to increased borrowing rates in the market.

We adopt two complimentary empirical strategies. The first consists of estimating panel regression models. Namely, we calculate the impact of visiting the DW on banks' excess equity returns and excess borrowing rates by estimating an equation of the following form:

$$(y_{it} - \bar{y}_t) = \beta_0 + \beta_1 DW_{it-2} + \beta_2 DW_{it-1} + \beta_3 DW_{it} + \beta_4 DW_{it+1} + \beta_5 DW_{it+2} + \nu_i + \epsilon_{it} \quad (6.1)$$

where y_{it} is either the daily equity return or the percentage change in the overnight borrowing rate in the fed funds market for bank i at date t, $\bar{y}_t$ is the cross-sectional average of y_{it}, $DW_{i\tau}$ is a dummy variable equal to one if bank i visits the DW on date τ, and ν_i is a bank specific random effect. $\bar{y}_t$ is intended to capture market wide effects that affect equity returns or borrowing rates of all banks on a particular day.The β coefficients give the estimated difference in the dependent variable between banks that visit the DW on date τ and those that do not. By varying τ relative to t, we can examine the effects of visits to the DW prior to or after date t. Equation (6.1) is estimated using all DW eligible financial institutions between January 2, 2007 and September 22, 2010. Standard errors are block-bootstrapped to further eliminate over-rejection due to the time-series elements of the data, as suggested by Bertrand, Duflo, and Mullainathan (2004).

The second strategy relies on matched samples. Specifically, we paired each bank visiting the DW to another bank that is similar in asset size but never visited the DW during our sample. For borrowing rates, the matched bank was required to borrow from the overnight fed funds market for at least 40 percent of the days during which the DW visiting bank also borrowed in the fed funds market. For equity returns, a matched bank must have non-missing stock returns on at least 50 % of the days in which a bank visiting the DW also had non-missing returns. We then estimated the difference in the percent change in the overnight fed funds borrowing rates and equity returns between the DW visitor and the corresponding matched bank.

In interpreting our results, it is important to keep in mind the source of the data on borrowing ratesThe overnight borrowing rates are computed with a two-step procedure. The first step consists of inferring for each bank all of its overnight fed funds transactions in a given day using proprietary Fedwire payments data (the real-time gross settlement system operated by the Fed, where most fed funds transactions are settled). This inference is based on a version of the algorithm used in Furfine (2003). The second step consists of computing a daily weighted average of fed funds borrowing rates for each bank using the volume associated with each fed funds transaction inferred in step one as the weight. The inference used in this paper relies on the algorithm correctly identifying individual federal funds transactions. However, as mentioned earlier,attempts to validate the accuracy of the algorithm have so far not been successful. In particular, the probability that any given pair of transactions which the algorithm identifies as federal funds, are in fact federal funds, is not known. As a result, there is uncertainty regarding the quality of the estimates produced in the second step.

In Table 6, we show results from the matched samples and from estimating equation (6.1) for the daily equity return (respectively columns 1 and 2) and the percentage change in overnight interbank market borrowing rates (respectively columns 3 and 4) for banks visiting the DW relative to banks that did not visit the DW. The β coefficient estimates are reported in each row under *Stock Returns* and *Borrowing Rates*. The first two rows of estimates ($t-2$ and $t-1$) show the impact of the two days prior to visiting the DW. These results should only be significant if a bank's counter parties receive an informative signal about a bank's future plans to visit the DW or if there is reverse causality (i.e. changes in the dependent variables drive the bank to visit the DW). The next three rows (t through $t+2$) show the change in the borrowing rate on the day of a bank's DW visit or on the two days after visiting the DW. We include the two days after visiting the DW to allow for gradual discovery of a bank's

DW visit by the market.

None of the parameters reported in the first column of Table 6 is significantly different from zero. In other words, our matched sample approach suggests that the changes in stock prices are not different whether or not a bank visited the DW. In contrast, the results reported in the second column of Table 6 show a negative stock return of almost 30 basis points on the day of DW visits, relative to banks that do not visit the DW. There is no effect on stock returns on days prior to or after DW visits.

Results reported in columns 3 and 4 of Table 6 indicate that on the days prior to visiting the DW, a bank does not experience significantly higher borrowing rates compared to banks that did not visit the DW. In contrast, our results indicate that borrowing rates increase significantly on the day a bank visits the DW (see column 4), or on the day after a DW visit (see column 3), although the latter effect is partially offset on the following day (i.e. t+2). More specifically, our panel estimation suggests that, relative to banks that do not go to the DW, a bank's borrowing rate increases on average by 0.8 % on the day it visits the DW. The matched sample estimation suggests that, relative to banks that do not go to the DW, a bank's borrowing rate increases on average by 1.4 % on the day after its DW visits, although roughly half of this effect is offset on the following day. To put these results in perspective, note that the average borrowing rate was about 3 % during our sample period. As a result, the panel data results imply an increase in borrowing rates of about 2.4 basis points (i.e. 0.8 % of 3 %) on the day of the DW visit, while the matched sample results imply an increase of about 4.2 basis points in borrowing rates on the day after a DW visit.

In unreported results, we have also examined the effect of DW visits on the CDS prices of banks and, although CDS prices were higher for banks visiting the DW compared to banks that did not, the increase was not statistically significant. One reason for the lack of significance might be that CDS prices are not available for a large number of banks which reduces the power of the statistical tests.

To sum up, although the evidence produced by our two estimation strategies is not perfectly consistent, our results are generally consistent with the hypothesis that banks visiting the DW may face a moderate increase in borrowing costs and a moderate decrease in stock prices.

7 Conclusion

As the opening quote from Chairman Bernanke illustrates, DW stigma is generally considered to hinder the Fed's ability to supply liquidity to banks. There is, however, little empirical evidence to support this commonly accepted hypothesis. In this paper, we provide rigorous empirical evidence for the existence of DW stigma during the financial crisis that began in 2007. In particular, we find that, consistent with the existence of DW stigma, banks regularly submitted TAF bids above the prevailing DW rate. We also identify several determinants of the incidence of DW stigma, including bank characteristics (e.g. size), proxies for market funding conditions (e.g. LIBOR-OIS spread), and policy variables (e.g. DW penalty rate). Moreover, we find that banks were willing to pay a premium of at least 37 basis points on average to borrow from the TAF instead of the DW. Immediately after the bankruptcy of Lehman Brothers, this premium increased sharply to at least 150 basis points, most of which cannot be explained by deteriorating market risk factors. Finally, we find that the economic costs of DW stigma are relevant. In particular, if banks had used the DW facility instead of the TAF during the summer of 2008, then they would have saved 5.5 million dollars per auction on average. Finally, we find some evidence consistent with the hypothesis that the banks' beliefs about DW stigma may be rational.

Our results have policy implications on how central banks can effectively supply liquidity during crisis periods. Indeed, an important lesson of this paper is that, although DW stigma is real and economically relevant, its magnitude is hard to measure precisely. As a result, it becomes virtually impossible to predict the extent to which the DW rate needs to be adjusted in order 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 simultaneously to a broad set of banks. 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 attempted to do in December 2007 when it introduced the TAF. Indeed, several features of the TAF were specifically designed to remove any of the stigma concerns that were attached to the DW.

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 with respect to the market

is that the identity of borrowers is inferred by market participants. Arguably, the recent initiatives aimed at promoting more transparency in the Fed's liquidity programs could facilitate the identification of DW borrowers. This increased transparency could potentially enhance DW stigma, which in turn could impede the Fed's ability to act as an effective lender of last resort. Recognizing the possible adverse consequences of real-time disclosure, the Dodd-Frank *Wall Street Reform and Consumer Protection Act* passed in July 2010 requires the Fed to make public the identity of DW borrowers only after a lag of two years.

Note also that, although our analysis pertains to central bank liquidity supply during crisis periods, understanding DW stigma may be important for monetary policy implementation in normal times. Many central banks now conduct monetary policy by keeping interest rates within a "corridor" where the floor of the corridor is given by the standing deposit facility rate (or the interest on excess reserves, in the Fed's case) and the ceiling is expected to be the DW rate. The existence of DW stigma therefore raises the ceiling of the corridor. Furthermore, since the magnitude of DW stigma cannot be estimated precisely, there is uncertainty regarding the ceiling's location. As a consequence, the central bank may have difficulty controlling the ceiling of the corridor.

More generally, the issue of stigma in financial markets may apply beyond the Fed's DW facility. In particular, it may apply to other U.S. government programs, as well as non-U.S. central bank liquidity facilities. For example, at the end of 2008, the U.S. Treasury used the TARP to recapitalize the banking sector. Some of the financial institutions that accepted the government's financial assistance were subsequently branded by the financial press as having "TARP stigma".[30] Moreover, as Llewellyn (2008) and Lumsdaine (2009) note, the announcement that Northern Rock had sought liquidity assistance from the Bank of England, triggered an immediate run on its deposits. Our paper should therefore be considered a first step towards understanding the general problem of stigma in financial markets.

[30]Press coverage on TARP stigma includes *The New York Times* December 3rd, 2009 (*Move to Repay Aid Helps Bank of America Shed Stigma*) regarding Bank of America and NPR coverage on April 1, 2009 regarding smaller regional banks, see respectively: `http://dealbook.nytimes.com/2009/12/03/move-to-repay-aid-helps-bank-of-america-shed-stigma/`, and `http://www.npr.org/templates/story/story.php?storyId=102618967`.

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Appendix - Data Description and Variable Descriptions

The data may be grouped into five categories: (1) TAF auction activity, (2) DW activity, (3) bank characteristic, (4) market variables, and (5) policy variables. With some exceptions, the data covers 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 over-subscribed auction. The TAF bid data are from the Federal Reserve Bank of New York. They contain observations of bid amounts, award amounts, and bid rates for all bids submitted by banks at TAF auctions. In addition, the TAF data include the stop-out rates at each auction as published by the Federal Reserve Board. The universe of TAF eligible banks and their collateral postings at the Fed on each auction date are from the Federal Reserve Bank of New York. Data on DW visits from primary credit loans are from the Federal Reserve Bank of New York. We use DW activity data from January 2, 2007 to September 22, 2010.

Bank asset values are obtained from the Fed's Call and Thrift Reports. Stock price data are obtained from CRSP abd CDS data are from Markit. The fed funds effective rate and the standard deviation of the fed fund rates are estimated on a daily basis by the Markets Group at the Federal Reserve Bank of New York based on fed funds brokers reports. U.S. LIBOR rates (one month maturity) are from the British Banker's Association. The Overnight Indexed Swap (OIS) - also one month maturity - is obtained from Bloomberg. The policy variables, namely the fed funds target and the DW penalty rate, are obtained from the Federal Reserve Board. The following explanatory variables are used to produce the results reported in Tables 3 and 4: (1) *Log of assets* refers to the log of quarterly assets, (2) *Log of pledged collateral* is the log of total collateral pledged to the Fed prior to each TAF auction, (3) *Pledged collateral increased* is a dummy variable equal to 1 if a bank increased its pledged collateral from the previous TAF auction, (4) *Bank bid at previous auction* is a dummy variable equal to 1 if the bank bid at the previous TAF auction, (5) *Awarded funds at previous auction* is a dummy variable equal to 1 if the bank was awarded funds at the previous TAF auction, (6) *Bid above DW at previous auction* is a dummy variable equal to 1 if a bank bids above the DW rate at the previous TAF auction, (7) *Days in last week bank took DW loan* is the number of days that a bank took out DW loans in the week prior to the TAF auction, (8) *Banks taking DW loans week before* refers to the total number of banks that received DW loans in the week prior to the TAF auction, and finally (9) *After DW Penalty Change*, is a dummy variable equal to 1 for each auction after March 16, 2008. Summary statistics of the variables appear in Table 2.

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 H.4.1*. The dates of the sale of Bear Stearns and the bankruptcy of Lehman Brothers are indicated by vertical lines.

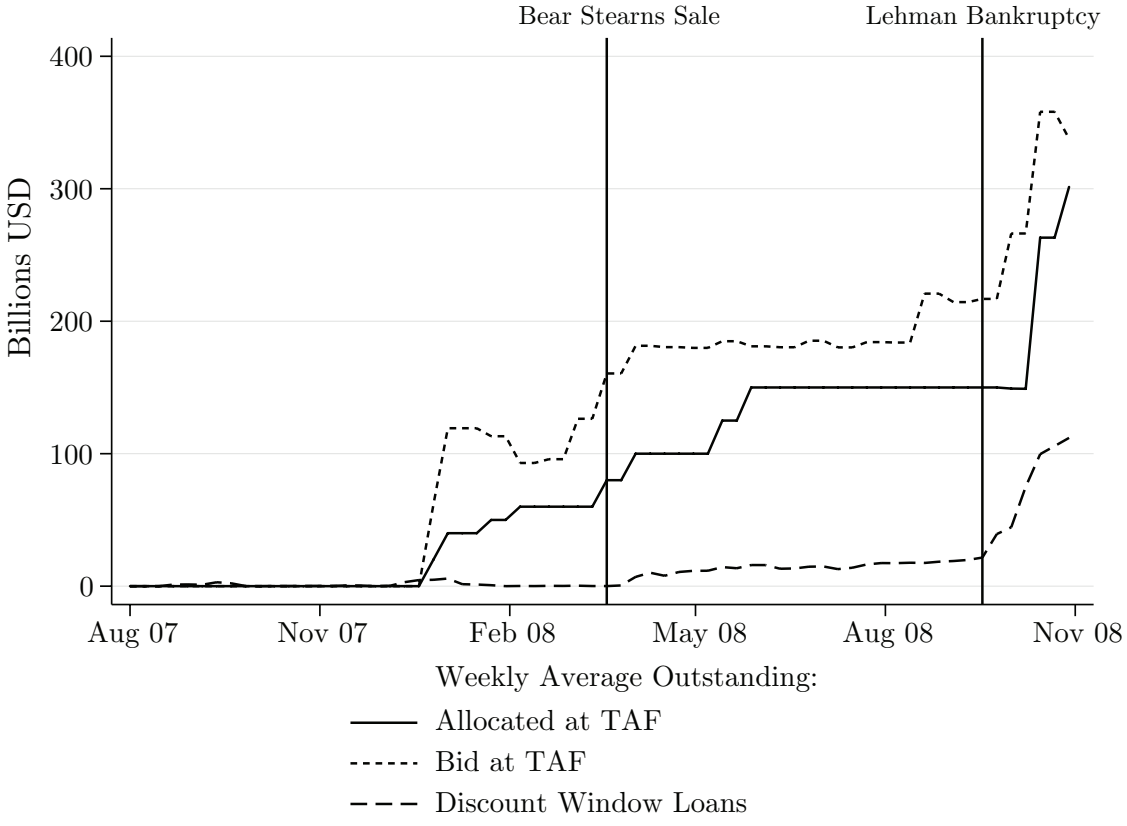

Figure 2: Participation at the TAF and DW

The figure displays monthly averages of the number of banks bidding at TAF auctions (solid line) and borrowing at the DW (dashed line). The number of TAF bidders is reported by the Federal Reserve Board. The number of banks receiving DW loans is from the Fed System *Monthly Report on Credit and Liquidity Programs*. The dates of the sale of Bear Stearns and the bankruptcy of Lehman Brothers are indicated by vertical lines.

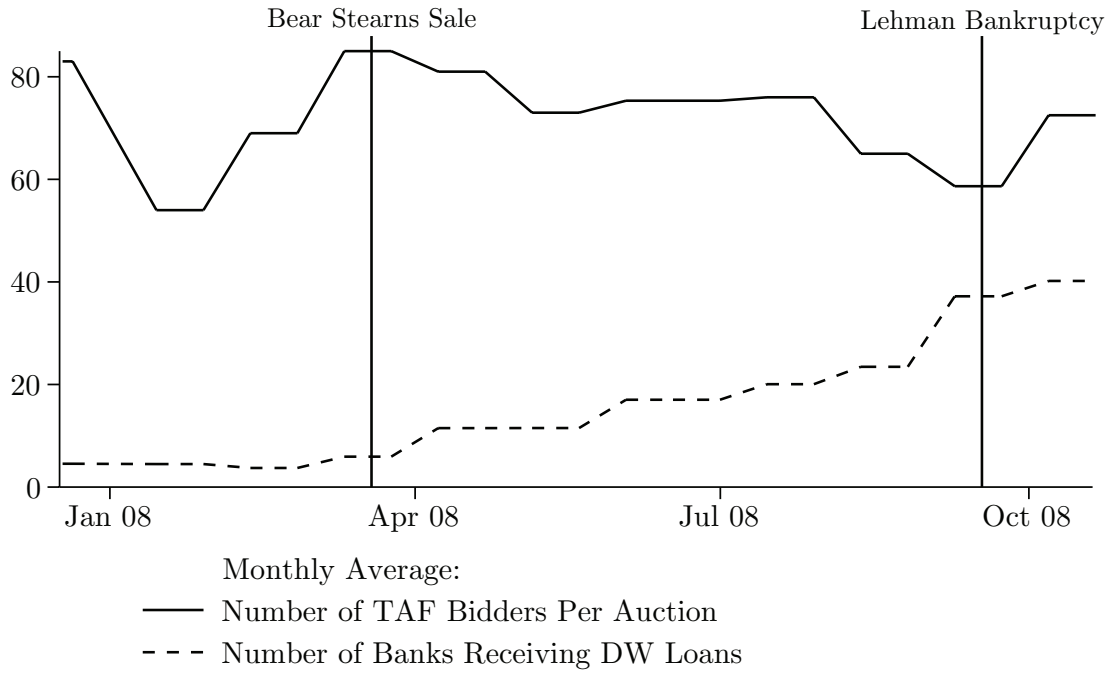

Figure 3: Bidding Above Maximum Willingness to Pay is Weakly Dominated

If a bank bids at a TAF auction above its maximum willingness to pay (MWTP) for funds from the Fed, three potential outcomes could result depending on the stop-out rate at the auction. In each of the outcomes the bank does at least as well, and in outcome 3 does strictly better, if it bids at or below its MWTP for funds from the Fed.

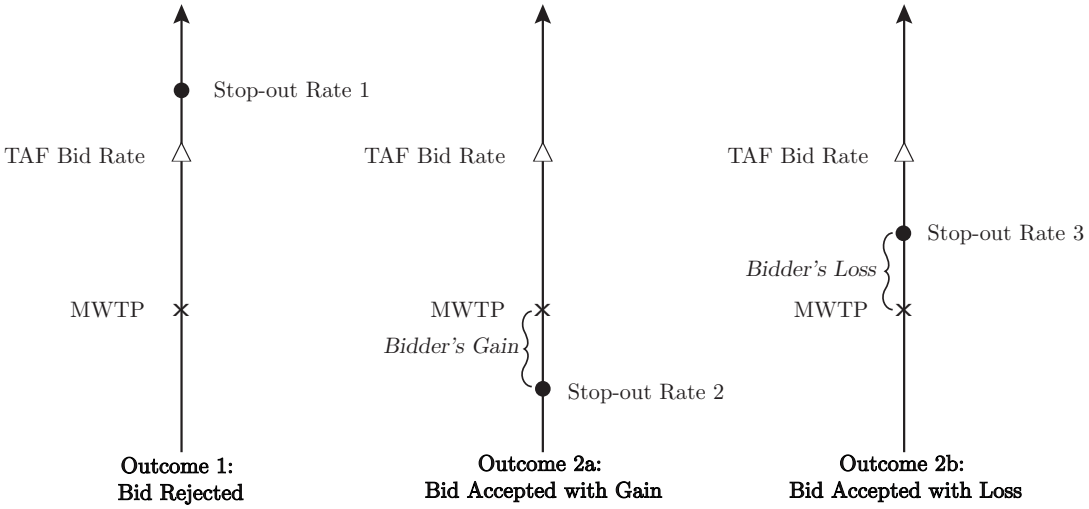

Figure 4: TAF Bids Above the DW Rate

The figure shows the share of banks that submit a TAF bid above the DW primary credit rate. If a bank submits two bids, only the bid with highest rate is considered. Auctions with a stop-out rate above the DW primary credit rate are indicated by solid circles, while auctions with a stop-out rate below the DW primary credit rate have hollow circles. The reduction in the DW penalty spread from 50 to 25 basis points on March 16, 2008 is indicated by the first vertical line and the date of the Lehman Brothers bankruptcy, September 15, 2008, by the second vertical line. Data sources are in the Appendix.

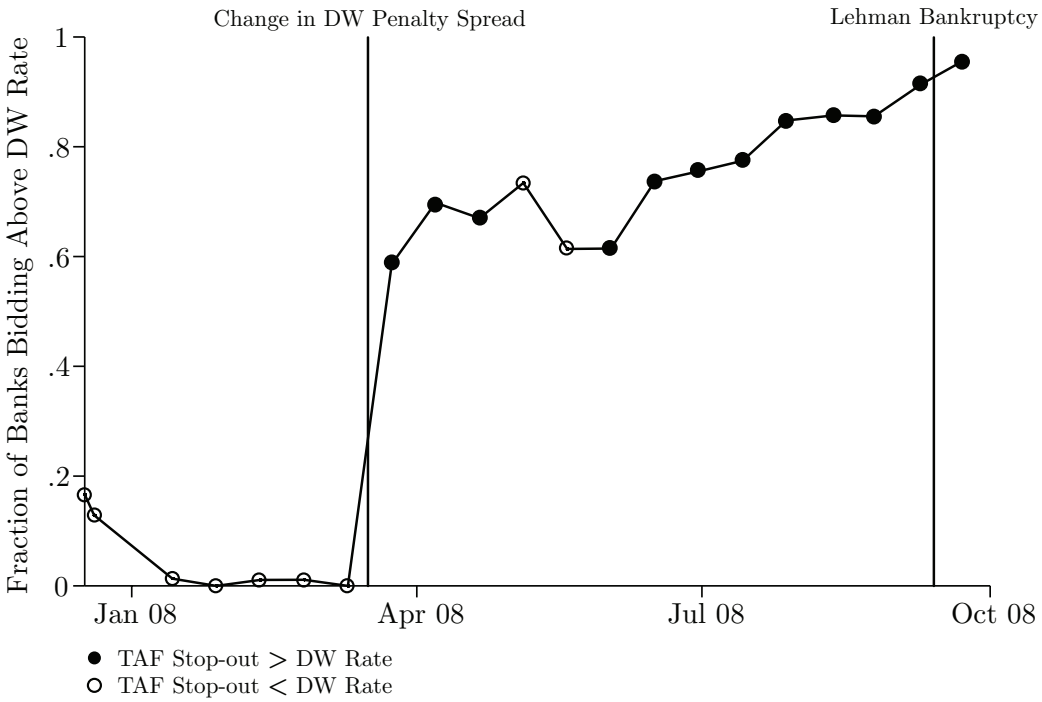

Figure 5: Banks Bidding Above DW Rate - Frequency Distribution

The figure shows the distribution of the percent of TAF auctions in which a bank bids above the DW primary credit rate. The X-axis values are calculated as 100*(number of TAF auctions where a 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 vertical line indicates that half of the banks that submitted a bid above the DW rate did so in at least 67 % of the auctions in our sample. The 25th percentile line indicates that 25 % of the banks that submitted a bid above the DW rate did so in at least 50 % of the auctions in which they participated. 38 out of 178 TAF participants in our sample submitted bids above the DW rate at every auction in which they participated.

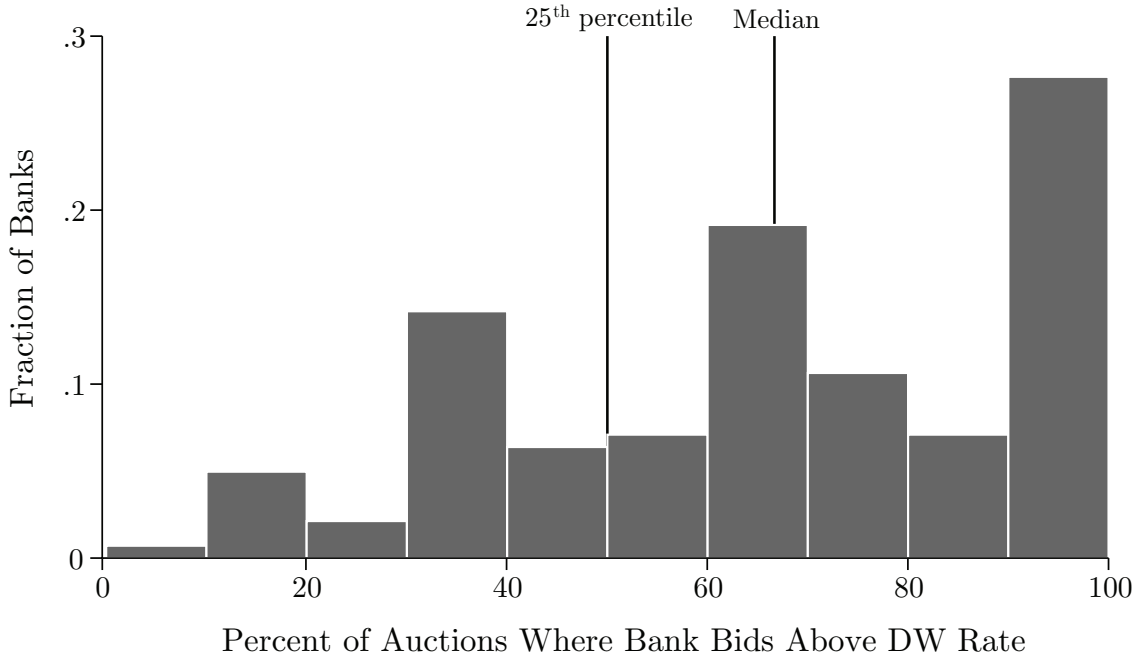

Figure 6: Effects of Changes in DW Penalty and Target Rate on the Incidence of Stigma

The figure illustrates how the incidence of DW stigma may change when either the DW penalty rate (Scenario 1) or the fed funds target rate (Scenario 2a and Scenario 2b) change. MWTP is a bank's maximum willingness to pay for funds from the Fed. The subscripts t and $t+1$ refer to periods before and after the change in either the DW penalty rate or the fed funds target rate. In Scenario 1, there is a decline in the DW penalty rate under the assumption that the MWTP does not change. In Scenario 2a, there is a decline in the target rate which results in a relatively small reduction in the MWTP. In contrast, in Scenario 2b, there is a decline in the target rate which results in a relatively large reduction in the MWTP.

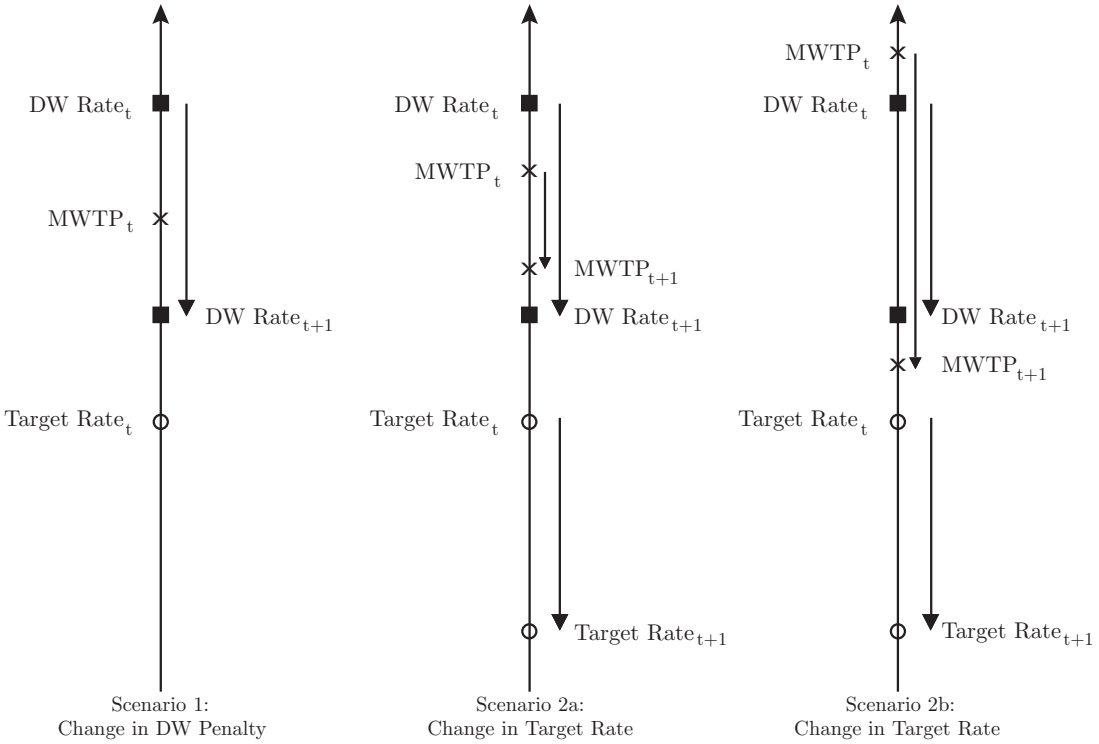

Figure 7: DW Stigma Premium and Realized DW Stigma Premium

The figure illustrates the three different concepts of DW stigma rate, DW stigma premium, and realized DW stigma premium. Scenario 1 illustrates how a bank at three different time periods or three different banks at the same time can have the same DW stigma rate and premium but different realized DW stigma premium. Scenario 2 illustrates the effect of lowering the DW penalty rate on the DW stigma premium and the realized DW stigma premium under the assumption that the DW stigma rate remains constant.

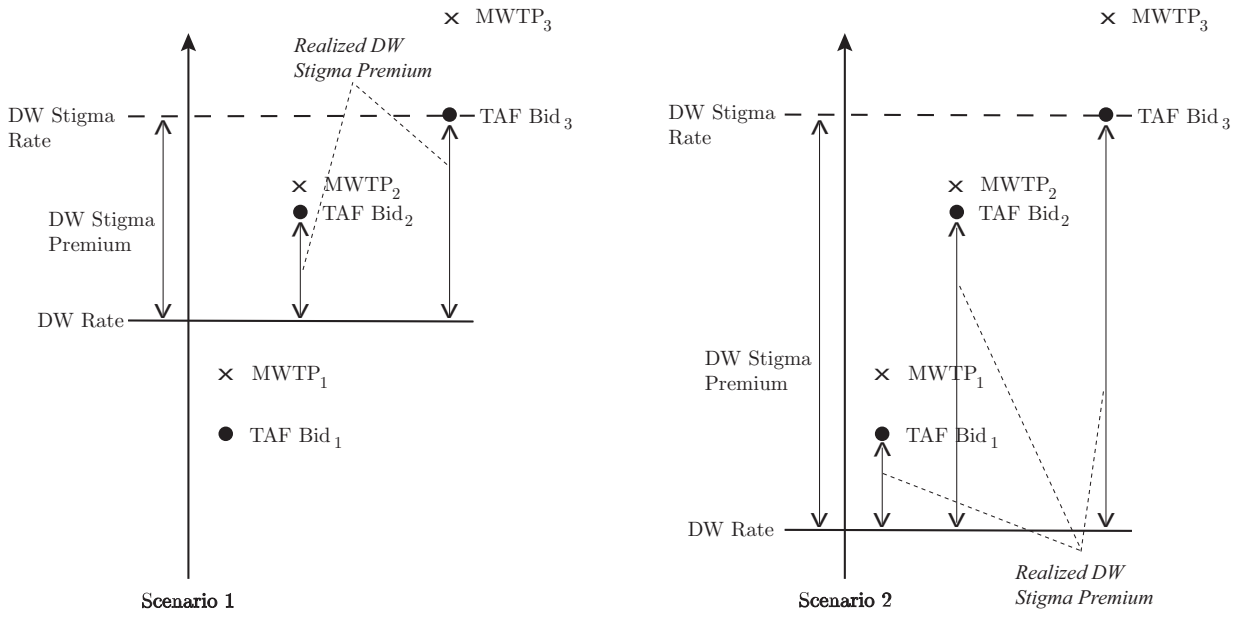

Figure 8: Average Realized DW Stigma Premium

For a bank that bids above the DW rate, the realized DW stigma premium is calculated as the difference between the bank's highest TAF bid rates and the DW primary credit rate. Solid circles indicate that the auction stop-out rate is above the DW primary credit rate; hollow circles indicate that the stop-out rate is below the DW primary credit rate. The reduction in the DW penalty from 50 to 25 basis points on March 16, 2008 is indicated by the first vertical line and the date of the Lehman Brothers bankruptcy, September 15, 2008, by the second vertical line.

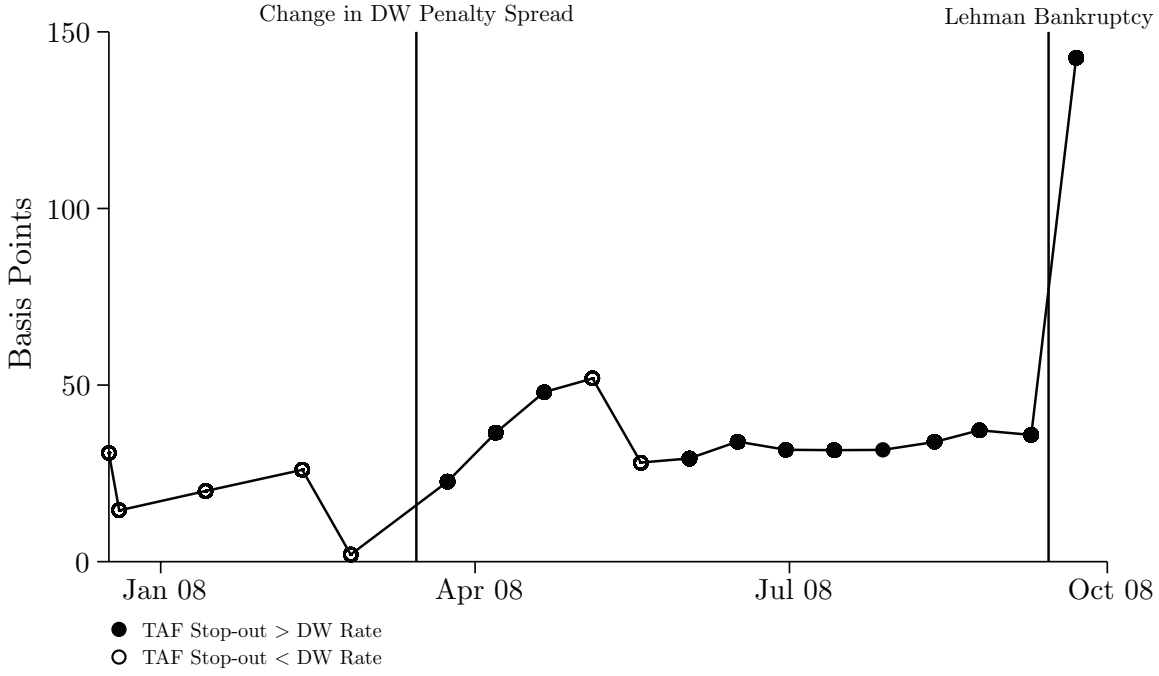

Table 1: Comparison between the TAF and DW programs: December 2007 to September 2008

Similarities

	Term Auction Facility	**Discount Window (Primary Credit)**
Collateral	Same as DW for 28 day loans, wiht additional collateralization of 25 % required on 84-day loans	Same set of collateral allowed as 28-day TAF auctions
Eligible Bank	Primary credit eligible banks, considered to be in good standing by its regional Federal Reserve Bank, and with enough collateral to make the minimum TAF bid	All banks with reserve account and high supervisory rating
Minimum bid or loan amount	$ 10 million until February 1, 2008, $ 5 million after that	None
Identification	Identity of TAF borrowers and bidders is not revealed	Identity of DW borrowers is not revealed

Differences

Frequency	Generally once every two weeks	Any time during normal business hours
Loan Term	Generally 28 or 84 days	Overnight through 30 days before March 17, 2008 and 90 days thereafter, renewable by borrower
Maximum bid or loan amount	10 percent of total auction size or up to available collateral (whichever is smaller)	Up to available collateral
Prepayment	Not possible	Allowed without cost
Rate	Determined through competitive bidding at an auction	Spread over fed funds target rate (target+50 bp until March 16, 2008; target+25 bp after)

Table 2: Summary Statistics

Variables and data sources are defined in the Appendix.

Variable	Number of observations (Bank-Auction Pairs)	Mean	Median	Standard Deviation	Min	Max	Dummy Variable? (Y/N)
Bid above discount window rate	1540	0.56	1	0.50	0	1	Y
Log of assets	1508	9.74	9.81	1.89	4.87	14.16	N
Log of pledged collateral	1537	7.60	7.96	2.05	2.28	11.47	N
Increase in pledged collateral	1540	0.49	0	0.5	0	1	Y
Bid at previous auction	1540	0.67	1	0.47	0	1	Y
Awarded funds at previous auction	1540	0.41	0	0.49	0	1	Y
Fed funds standard (in %) deviation	1540	0.25	0.15	0.20	0.06	0.92	N
LIBOR-OIS spread (in %)	1540	0.55	0.46	0.24	0.23	1.25	N

Table 3: Determinants of the incidents of DW Stigma

The dependent variable equals 1 when a bank bids above the DW primary credit rate and zero otherwise. The baseline probit model appears in equation (4.1) and the regressors are defined in the Appendix. The panel estimation method accounts for bank specific random effects. The sample includes all bank-auction pairs for 28-day, fully subscribed TAF auctions from December 17, 2007 to September 22, 2008. The standard errors are corrected for heteroskedasticity. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

VARIABLES (Coef. eq. (4.1))	(1) Baseline	(2) Policy Change	(3) DW Participation
Log of assets (α_1)	-0.15***	-0.20**	-0.20**
	(0.05)	(0.09)	(0.08)
Log of pledged collateral (α_2)	0.15***	0.21***	0.17**
	(0.04)	(0.08)	(0.07)
Pledged collateral increased (α_3)	0.47***	0.20	0.19
	(0.09)	(0.12)	(0.12)
Bank bid at previous auction (α_4)	-0.81***	-0.67***	-0.51***
	(0.12)	(0.15)	(0.16)
Awarded funds at previous auction (α_5)	0.09	0.12	0.28
	(0.14)	(0.18)	(0.18)
Bid above DW at previous auction (α_6)	2.20***	1.18***	0.88***
	(0.12)	(0.16)	(0.17)
Fed funds standard deviation (α_7)	0.019***	0.006	-0.002
	(0.002)	(0.004)	(0.005)
LIBOR-OIS spread (α_8)	0.006**	0.007**	0.008**
	(0.002)	(0.003)	(0.004)
After DW penalty change		4.29***	4.37***
		(0.52)	(0.57)
Fed funds target rate		0.008***	0.011***
		(0.003)	(0.003)
Days in last week bank took DW loan			-0.65***
			(0.14)
Banks taking DW loans week before			0.03***
			(0.005)
Constant (α_0)	-0.70**	-5.33***	-6.46***
	(0.31)	(1.12)	(1.22)
Observations	1505	1505	1505
Number of Unique Banks	178	178	178
Log Likelihood	-638.6	-436.3	-411.9

Table 4: Determinants of Realized DW Stigma Premium

The dependent variable is the realized DW stigma premium (in basis points), defined as the difference between a bank's TAF bid rate and the DW primary credit rate, conditional on the bank bidding above the DW primary credit rate. If the bank submitted two bids, only the higher of the two bids is considered. The regressors are defined in the Appendix. The panel estimation method accounts for bank specific random effects. The sample includes all bank-auction pairs for which the TAF bid rate was above the DW primary credit rate at 28-day, fully subscribed TAF auctions. Heteroskedasticity robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)
VARIABLES	Baseline	Policy Change	DW Participation
Log of assets	-5.25**	-5.18**	-4.96**
	(2.06)	(2.03)	(2.02)
Log of pledged collateral	3.88**	3.78**	3.51**
	(1.84)	(1.79)	(1.77)
Pledged collateral increased	5.53**	4.38*	4.39*
	(2.53)	(2.55)	(2.53)
Bank bid at previous auction	-4.23	-2.14	-0.62
	(3.15)	(3.21)	(3.12)
Awarded funds at previous auction	2.07	2.35	3.89
	(3.71)	(3.70)	(3.77)
Bid above DW at previous auction	10.69***	6.33**	4.17
	(2.31)	(2.66)	(2.86)
Fed funds standard deviation	-0.06	-0.06	-0.05
	(0.07)	(0.07)	(0.07)
LIBOR-OIS spread	0.30***	0.50***	0.61***
	(0.06)	(0.07)	(0.08)
After Lehman bankruptcy	100.82***	83.72***	67.95***
	(12.68)	(13.32)	(14.14)
Fed funds target rate		-0.22**	-0.18**
		(0.09)	(0.09)
After DW penalty change		-24.53	-15.94
		(19.86)	(18.24)
Days in last week bank took DW loan			-11.88*
			(6.26)
Banks taking DW loans week before			0.22***
			(0.07)
Constant	28.89**	90.81**	58.53
	(14.60)	(40.28)	(38.45)
Observations	840	840	840
Number of Unique Banks	137	137	137
R-squared	0.463	0.467	0.474

Table 5: Banks' Cost of Bidding Above DW Rate

We report potential and realized costs for banks that bid above the DW rate. **Panel A:** Potential cost is calculated as the dollar value of a bank's bid amount times the spread between the bank's TAF bid rate and the DW rate times the term of the loan divided by 360. *Total per Auction* is the sum of all individual bank potential costs, averaged over all auctions in our sample. *Average per Bank per Auction* is the average potential cost at each auction for each participating bank. *Potential Cost/Potential Interest Paid* is the total potential cost divided by the total interest these banks would have paid if charged interest at their bid rates. **Panel B:** Realized cost is the amount of interest that a bank paid in excess of the DW conditional on the TAF stop-out rate being above the DW rate. Realized cost is calculated as the dollar value of funds awarded at the TAF times the spread between the stop-out rate and the DW rate times the term of the loan divided by 360. *Total per Auction* is the sum of individual bank actual costs, averaged over the 21 auctions in the sample. *Average per Bank per Auction* is the average actual cost at each auction for each bank. *Bid Above Cost/Actual Interest Paid* is the total value paid above the DW rate divided by the total interest these banks paid on interest for their TAF loans. The full sample is all 28-day fully subscribed auctions, the summer of 2008 is the subset of these auctions from March 24, 2008 through September 8, 2008, and Lehman is the single auction on September 22, 2008.

Panel A: Potential Cost

	Full Sample	Summer 2008	Lehman
Total per Auction (millions USD)	17.8	15.9	164.4
Average per Bank per Auction (millions USD)	0.43	0.26	2.05
Potential Cost/Potential Interest Paid	12.3 %	12.4 %	46.5 %

Panel B: Realized Cost

	Full Sample	Summer 2008	Lehman
Total Cost per Auction (millions USD)	6.7	5.5	74.7
Average per Bank per Auction (millions USD)	0.25	0.10	2.41
Bid Above Cost/Actual Interest Paid	9.1 %	5.6 %	40.0 %

Table 6: Changes in Asset Prices After DW Visits

The first two columns of the table show the difference in stock returns of banks visiting the DW relative to banks that did not. **Column 1:** shows results using a matched sample methodology. Banks are matched by asset size, with each DW visitor assigned a unique match for the full sample. A matched bank must have non-missing stock returns on at least 50 % of the days in which a DW visiting bank also had non-missing returns. The reported value is the difference in stock returns for a DW visitor and its matched pair. **Column 2:** shows the impact on stock returns of banks' DW visits using the panel regression appearing in equation (6.1). The dependent variable is the bank's daily stock return minus the cross-sectional average of the stock returns of all banks on that day. The third and fourth columns of the table show the percent change in borrowing costs of banks visiting the DW relative to banks that did not. In **Column 3:** the impact of DW visits is calculated as the difference in the percent change in overnight fed funds borrowing rate between a bank that visits the DW and a matched bank that does not. The matched bank is required to borrow in the fed funds market on at least 40 % of the days during which the DW visiting bank borrowed. **Column 4** shows the impact on borrowing rates of banks' DW visits using the panel regression appearing in equation (6.1). The dependent variable is the percent change in overnight fed funds borrowing rate minus the cross-sectional average for each bank that participated in the fed funds market. For the panel regression, standard errors are calculated with block bootstrapping within bank clusters. Standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

	Stock Returns		**Borrowing Rates**	
	Matched Samples	Panel Regressions	Matched Samples	Panel Regressions
t-2	0.07	-0.01	0.08	0.13
	(0.145)	(0.15)	(0.63)	(0.30)
t-1	-0.02	0.06	-0.33	-0.40
	(0.142)	(0.13)	(0.60)	(0.28)
t	-0.09	-0.28***	0.42	0.80*
	(0.14)	(0.13)	(0.72)	(0.46)
t+1	0.09	0.20	1.36**	0.11
	(0.14)	(0.12)	(0.66)	(0.43)
t+2	-0.11	-0.03	-0.75*	-0.59
	(0.14)	(0.13)	(0.46)	(0.20)
N	3,266	274,216	393	69,599