Journal of Banking and Finance 76 (2017) 92–119

Contents lists available at ScienceDirect

Journal of Banking and Finance

journal homepage: www.elsevier.com/locate/jbf

Thawing frozen capital markets and backdoor bailouts: Evidence from the Fed's liquidity programs☆

Jean Helwege[b], Nicole M. Boyson[a], Jan Jindra[c,*]

[a] Northeastern University, Boston, MA02186, USA
[b] University of California,Riverside, CA92508, USA
[c] Securities and Exchange Commission, 44 Montgomery Street, San Francisco, CA94104, USA

ARTICLE INFO

Article history:
Received 1 November 2015
Accepted 21 November 2016
Available online 7 December 2016

Keywords:
Crisis
Federal reserve
Discount window
TAF
PDCF
TSLF
Bailout
Liqudity

ABSTRACT

During the subprime crisis, the Federal Reserve introduced several emergency liquidity programs as supplements to the discount window (DW): TAF, PDCF, and TSLF. Using data on loans to large commercial banks and primary dealers, we find that the programs were used by relatively few institutions and thus provided limited relief to banks that relied on short-term debt markets. Although usage increased after Lehman's bankruptcy, most commercial banks avoided the DW and TAF. We also find that the programs were more often used by failed European banks than by healthy US banks, likely because these loans are expensive relative to private market funds. Our results also show that usage of PDCF and TSLF programs, while higher, was more often used by primary dealers in weaker financial position.

Published by Elsevier B.V.

"…in September [2008], after 13 months of market stress, the financial system essentially seized up and we had a system-wide crisis. Our markets were frozen, banks had pulled back very substantially from interbank lending."

(Testimony of Hank Paulson, Treasury Secretary, to the House Committee on Financial Services on November 18, 2008.)

To provide support to banks during the subprime crisis, the Federal Reserve (Fed) introduced three new loan facilities: the Primary Dealer Credit Facility (PDCF), the Term Securities Lending Facility (TSLF) and the Term Auction Facility (TAF).[1] Together with its discount window (DW) program, these new facilities were intended to expand the Fed's lender of last resort (LOLR) role in a time of extreme market stress. The PDCF and TSLF were created to allow Fed loans for primary dealers, who would otherwise have had to fend for themselves in the subprime crisis. The TAF and TSLF were structured to minimize the effects of stigma, which the Fed had viewed as the main impediment to greater DW borrowing in previous downturns (Madigan and Nelson (2002)).[2]

Extant research on DW stigma suggests that it is the reason for the historically low usage of DW loans but since the names of DW loan recipients are kept secret, it is not obvious how a healthy bank would be stigmatized by accepting a Fed loan. Perhaps the answer lies in the tendency for DW loans to be given to banks that subsequently fail, despite Bagehot (1873) dictum to lend freely in a crisis to *sound* banks against good collateral. Fed data reveal that hundreds of failing banks received DW loans for more than a year during the 1920s. Similar practices were followed in the late 1980s when 530 banks repeatedly rolled over DW loans before being shut down by the FDIC (Schwartz, 1992). Price (2012) adds the too-big-to-fail (TBTF) examples of Continental Illinois in 1984 and Penn Central in 1970 as further evidence that DW loans typically go to unhealthy banks. Boyd and Gertler (1994) describe the discount window as "a favorite tool used over the last decade to keep

☆ We thank Gary Gorton, the editor, and an anonymous referee for thoughtful comments and suggestions. We also thank Gerald Hanweck, Rene Stulz, Sergey Tsyplakov, Haluk Unal, seminar participants at the Office of the Comptroller of the Currency, University of Houston, University of Southern Carolina and Menlo College and participants at the Midwest Finance Association Conference and Ohio State Alumni Conference for helpful comments. Raluca Roman kindly provided assistance with TARP data. The Securities and Exchange Commission, as a matter of policy, disclaims responsibility for any private publication or statement by any of its employees. The views expressed herein are those of the author and do not necessarily reflect the views of the Commission or of the author's colleagues upon the staff of the Commission.

* Corresponding author.
E-mail addresses: jean.helwege@ucr.edu (J. Helwege), n.boyson@neu.edu (N.M. Boyson), jj@janjindra.com (J. Jindra).

[1] See Tables A.1–A.4 in the appendix for details on the Fed emergency facilities.

[2] See Peristiani (1998), Furfine (2001, 2003), and Armantier, Ghysels, Sarkar and Shrader (2011) for empirical studies of DW stigma.

http://dx.doi.org/10.1016/j.jbankfin.2016.11.019
0378-4266/Published by Elsevier B.V.

troubled large banks afloat." In this light, the decline in popularity of DW loans in the late 1980sdescribed by Peristiani (1998), may be best thought of as the result of healthier banks' avoiding being tarred with the DW brush.

Besides the stigma associated with them, DW loans are expensive. Unlike short-term secured loans in the repo market, DW loans carry a rate higher than the Fed Funds (FF) rate. This rate differential holds for the PDCF program as well, since the PDCF program is structured identically to the DW and has the same penalty rate over the FF rate. In contrast, private market secured loans typically carry lower interest rates than their unsecured loan counterparts (Benmelech and Bergman (2009), Fleming, Hruang and Keane (2009), and Hrung and Seligman (2015)).[3] Fig. A.1 shows that the DW rate exceeded the repo rate by 50 to 100 basis points during most of our sample period. Thus, banks would ordinarily shun these loans in normal times, when market liquidity is sufficient. Indeed, Flannery (1996) argues that in an economy with well-developed credit markets there is no need for LOLR loans in normal times.

When capital markets are frozen in a crisis, however, the penalty rate may be a small price to pay if other funding sources have dried up. Moreover, the penalty rates on DW and PDCF loans do not apply to the TAF and TSLF, which set their interest rates via auctions. Thus, the Fed's efforts at providing liquidity in the subprime crisis may have been more successful than in previous downturns. We investigate all four Fed facilities in the subprime crisis to determine how well the programs alleviated stress in short-term capital markets and to see if these programs were more successful in avoiding the bailouts typical of past DW loans.

We analyze two frameworks to characterize the use of Fed credit facilities. The first framework views these emergency liquidity programs as potential lifelines to firms in the financial sector when short-term debt markets are frozen ("liquidity provision" framework). This framework implies that as the crisis deepens and capital market lending dries up, more banks should use the loan programs and should borrow more money. Furthermore, the pressure should be most evident among banks that rely on short-term debt markets. Borrowing is expected to take place first via programs that do not charge a penalty rate (TAF and TSLF) and expand to costlier programs as the crisis continues. The framework predicts that these patterns should reverse as capital markets ease up.

The second framework for understanding LOLR borrowing focuses on the financial strength of the institutions (the "bailout" framework). Implicit in this analysis is the assumption that capital markets are not completely frozen and funds are available elsewhere, such as in the repo market (Gorton and Metrick, 2012) or from the Federal Home Loan Banks (FHLBs) (Ashcraft et al., 2010). The bailout hypothesis focuses on the (relatively) large incentive for weak banks to borrow from the Fed in a crisis. Weak banks may find that they face unsecured interest rates in the capital markets that are higher than the one-size-fits-all DW and PDCF rates, while healthier banks do not. All four programs lend against collateral, but if the Fed overvalues the collateral, its penalty rate may compare favorably to the unsecured rate faced by a weak bank, especially if its only unencumbered assets are of lower quality. If these conditions hold, then the LOLR programs of the recent crisis may not have been any more successful at providing liquidity to healthy financial institutions than in the past, and would have again largely served to bail out weak banks. Under the bailout framework, we should observe that healthy banks rarely borrowed from the Fed and the amounts borrowed are small relative to the funds obtained in short-term debt markets. This hypothesis reflects the view that the DW and PDCF rates are too high to be attractive to solvent banks with access to capital markets funding. While the TSLF and TAF may be more attractive to healthy banks, these programs may underserve them if insolvent banks bid more aggressively. Thus, a second hypothesis is that borrowing should be concentrated among the weaker banks rather than widely spread throughout the financial services industry, as insolvent banks have a greater incentive to win the auctions. Lastly, the bailout framework predicts that repayment of loans, to the extent it exists, is not related to general market conditions but to the health of the individual bank that borrows.

Our sample includes large U.S. commercial banks, investment banks and foreign banks – essentially all major financial institutions permitted to borrow directly from the Fed during the crisis. Many of these large firms had both commercial and investment banking arms and, thus had access to all four programs. We focus on large firms since the new Fed programs were intended to address frozen capital markets and these banks would have been exposed to the problems in short-term debt markets. In contrast, Berger et al. (2013) analyze the same Freedom of Information Act (FOIA) data, but limit the sample to banks that submit Call Reports, thus ignoring many large firms that would have been severely affected by disruptions in repo and public bond markets.[4] Acharya et al. (2014) also analyze large borrowers, but they restrict their analysis to the emergency facilities aimed at primary dealers (PDCF and TSLF).[5] Finally, unlike prior research, our analysis considers both Fed facilities and those provided by the FHLB system.

We find that the Fed liquidity programs provided some relief from the financial pressures of the subprime crisis. While our multivariate analyses show that reliance on short-term debt markets is a significant factor in determining program usage, the loans from the Fed were a relatively small part of banks' short-term funding. Notably, at the peak point of borrowing, nearly 80%, i.e., the vast majority, of short-term funding continued to be supplied by capital markets. Much of the lending was to weak foreign banks, which were the largest and most frequent users of DW loans. All four programs were used more heavily after the bankruptcy filing of Lehman Brothers on September 15, 2008, but even during this period they were largely shunned by commercial banks. The programs aimed at the primary dealers, the PDCF and TSLF, were used more widely, but borrowing remained concentrated throughout the crisis even among these firms. Finally, loan prepayments were not generally motivated by better market conditions, but rather by a desire among weaker banks to avoid investor scrutiny.

Overall, our findings imply that the Fed programs increased liquidity relative to previous crises, since the PDCF, TSLF and TAF were relatively more popular than the DW. However, the amount of funding provided was small relative to the size of these banks' short-term borrowings in capital markets and many healthy banks continued to avoid the programs altogether. Of course, it is possible that the situation would have been worse if the Fed did not offer

[3] Studies that compare yields on secured and unsecured debt typically find the opposite, but this owes to endogeneity (Benmelech and Bergman (2009)).

[4] Prior to a Freedom of Information Act (FOIA) lawsuit in 2011, use of the DW was not disclosed to the public. The FOIA data, which are described in detail in the appendix, are matched by name to datasets on bank financial information, such as Compustat in our case, and to Call Reports by Berger, Bouwman, Black and Duglosz (2013). The entity matched to the FOIA name may be at a different level than the borrower. For example, Berger et al. report substantial TAF borrowing by Chase Bank USA relative to its $79 billion in assets (as of year-end 2007), but we note that this borrowing is not substantial compared to the assets of JPMorgan Chase Bank ($1.3 trillion). The former bank did not report any repo borrowing but JPMorgan Chase Bank lists $99 billion in repo debt. Both entities have lower assets than the consolidated balance sheet of JPMorgan Chase & Co. ($1.6 trillion; Compustat).

[5] Studies using aggregate data include Wu (2011), Fleming, Hrung and Keane (2009), Hrung and Seligman (2015), McAndrews, Sarkar and Wang (2008), Christensen, Lopez, and Rudebusch (2013), Taylor and Williams (2009), and In, Cui and Maharaj (2012).

the new LOLR programs, but our results suggest that these programs could have been more widely used. We conclude that modest borrowing from these emergency programs owes at least in part to their high cost (the penalty rate on secured debt) and alternative sources of cheaper borrowing (FHLB advances and deposits). As a result, weak banks were more likely to use the programs, especially insolvent foreign banks that also received bailouts from their own governments.

The remainder of the paper is as follows: Section 1 discusses the framework for analyzing the extent of liquidity provision by the Fed and the sample. Section 2 presents results. Section 3 concludes. The appendix provides detailed information on the Fed liquidity programs and the FOIA data.

1. Analytical framework and sample

1.1. Analytical framework

We test two frameworks describing the use of the Fed liquidity facilities: the "liquidity provision" and "bailout" frameworks. The former framework explicitly assumes that capital markets froze at some point during the crisis, as indicated in prior research (e.g. Berger et al. (2013) and Afonso et al. (2011)) and the above-cited statement made by Secretary Paulson. While debt markets were stressed prior to the Bear Stearns deal in March of 2008, regulators did not declare debt markets frozen until September of that year. Thus, some firms that avoided Fed borrowing early in the crisis may have only later taken advantage of the emergency facilities. To account for this possibility, we analyze borrowing from the Fed facilities during the pre- and post-Lehman periods separately.[6] The second framework (bailout), articulated by Ennis and Weinberg (2013) and Artuc and Demiralp (2010), implicitly assumes that markets, while not functioning as normal, continue to provide some funds to the strongest financial institutions. In that case, weak banks may still borrow from the private markets, but given their high credit spreads, they are more likely to find DW loans cheaper than private market debt. We note that the bailout framework need not refer only to insolvent banks, but to any bank deemed at risk of violating the regulatory minimum amount of capital (undercapitalized banks). It is also possible that nearly all banks could borrow in private markets at rates that are more favorable than the penalty rates associated with DW and PDCF loans, in which the TSLF and TAF loans should have been more popular.

To capture the effects of weak balance sheets in this crisis period while avoiding multicollinearity, we create an insolvency index. The index is higher for firms that are closer to insolvency or already have negative net worth. It is the sum of the following indicator variables: whether equity capital divided by total assets is below the sample median, whether ROA is negative, whether nonperforming loans scaled by total assets are above the sample median, whether the market-to-book ratio is below the sample median, and whether the institution failed (or would have failed had it not been bailed out or merged with another institution).[7] We also measure the level of solvency with the Z-score as in Laeven and Levine (2009).

Our first set of hypotheses describing the use of the Fed programs is related to the aggregate amount borrowed and the amount of capital market funding such borrowing replaced. Specifically, the two frameworks predict different uses of the facilities:

H1 (Market funding replacement hypotheses)

H1A (Liquidity provision): *If the Fed liquidity facilities were effective in thawing frozen capital markets, financial institutions should have replaced a substantial portion of their short-term borrowing with loans from the Fed programs, especially the programs with market interest rates (TAF and TSLF).*

H1B (Bailout): *If the Fed liquidity facilities were used as bailouts, the capital markets should have continued to supply nearly all short-term borrowing to healthier banks.*

H2 (Pervasiveness of use hypotheses)

H2A (Liquidity provision): *If the Fed liquidity facilities were effective in thawing frozen capital markets, the use of the facilities should have become more widespread when capital markets froze. DW and PDCF loans should have gained in popularity as the crisis deepened,* i.e.*, as competition for TAF and TSLF funds forced some banks to seek higher rate loans.*

H2B (Bailout): *If the Fed liquidity facilities were used as bail outs, the use of the facilities at time of market turmoil should have been concentrated among undercapitalized banks.*

We test H1 by examining the time series patterns of aggregate borrowing in all four programs relative to the total amount of short-term debt on banks' and dealers' balance sheets. If the Fed facilities succeeded in providing liquidity to thaw frozen markets, we should observe that the emergency loans replaced a large fraction of short-term debt. Because the TAF and TSLF are less expensive, the market funding replacement hypothesis (H1A) also implies that these facilities should have been more widely used than the more expensive DW and PDCF loans. If, by contrast, Fed loans replace a small fraction of short-term debt, then the results are more consistent with the bailout hypothesis. There is no theoretical cutoff that determines what constitutes a large fraction of short-term debt replacement, however, previous research (Ashcraft et al., 2010; Boyson et al., 2014) indicates that many banks replaced capital markets debt with FHLB advances and insured deposits. Hence, we would not expect many banks to replace the majority of their short-term debt with Fed loans, even if short-term debt markets were completely frozen. Therefore, banks in our sample would need to substitute a sizeable minority of their short-term debt with LOLR debt for the evidence to be consistent with the liquidity provision framework.[8]

We test H2 by calculating daily Herfindahl indexes that measure the relative concentration of each bank's usage of each program and examining the changes in the indexes around the time of the Lehman bankruptcy, since it is after the Lehman bankruptcy that regulators declared credit markets frozen. If the Herfindahl-indexes decline sharply following the Lehman event, indicating that more institutions accessed the liquidity programs, we conclude

[6] Another possible important breakpoint in time is the date of the Bear Stearns deal, which we consider throughout the analysis. A third possibility is August 7, 2007 when the "quant shock" occurred (Kandhani and Lo ((2007)), but the FOIA data only provide information on borrowing starting in August 2007. We note that the first loan in the FOIA data was originated on August 9, 2007 and the amount of lending by the Fed during August 2007 is minimal.

[7] The indicator variable for failed banks includes mergers where the acquiring bank borrowed from the Fed even if the acquirer is healthy. For example, it includes the $47.9 billion that Barclay's borrowed for its purchase of Lehman assets. These loans are indirect bailouts and would never have been made had the healthy bank not taken over the weak one. A partial list of bailed out institutions accessing DW (and the maximum loan amount) includes Bank of Scotland ($5 billion), Depfa ($28.5 billion), Dexia ($37 billion), Fortis ($7 billion), and Royal Bank of Scotland ($8.4 billion). Examples of such institutions accessing the PDCF (and the maximum loan amount) includeBear Stearns ($28 billion), Lehman Brothers ($28 billion), Wachovia ($23 billion), and Merrill Lynch ($33.2 billion). We only consider loans around the time or shortly after the announcement of mergers with other entities or bankruptcy.

[8] Note that our data source for short-term debt reports quarter-end balances and does not include a separate item for Federal Reserve loans. We calculate these balances separately to avoid the problem of counting LOLR loans in the short-term debt total.

that the new Fed programs were more successful at providing liquidity to thaw frozen markets (accept H2A and reject H2B). If the index increases, the bailout framework gains support (accept H2B). We also examine the absolute level of the Herfindahl indexes in the post-Lehman period. If the indexes are high, we infer that disruptions in capital markets were not severe enough to affect most firms and that the programs were not very widely used (reject H2A). H2A also implies that the high cost of funds from the PDCF and DW would be relatively less expensive after Lehman, making those programs more popular once TAF and TSLF funds were exhausted.

Next, we consider the cross-sectional variation in the types of firms that access the Fed liquidity programs. Under the liquidity provision framework, the institutions most exposed to short-term debt markets should be more likely to borrow from the Fed. If the bailout framework is correct, weak institutions should be more likely to take advantage of the Fed programs because the penalty rate of the Fed loans is not institution-specific. That is, weak institutions do not face as high a relative penalty as healthy ones when borrowing from the Fed. Weak institutions with more short-term debt are even more likely to use the LOLR debt, since they have no incentive to replace (low cost) long-term debt. Specifically,

H3 (Loan initiation hypotheses)

H3A (Liquidity provision): *If the Fed liquidity facilities were effective in thawing frozen capital markets, financial institutions with high (low) exposure to capital markets should have been more (less) likely to access the Fed programs.*

H3B (Bailout): *If the Fed liquidity facilities were used as bailouts of undercapitalized institutions, financially weak (strong) institutions should have been more (less) likely to access the Fed programs during times of market turmoil. Among weak institutions, those with more short-term debt should have been more likely to obtain loans.*

We test the liquidity provision loan initiation hypothesis (H3A) by examining firms' prior reliance on short-term debt markets. H3A predicts that firms with high short-term debt and low deposits are more likely to access the Fed programs after Lehman fails. We also consider the type of collateral posted when borrowing from the Fed. According to Gorton and Metrick (2012), when the repo market froze in 2008, MBS repo lending was particularly distressed. Thus, the use of MBS collateral for Fed loans should have increased sharply when repo markets froze. Finally, H3A implies that the Fed lending programs should have been at least as popular, if not more so, than FHLB advances.

With respect to the bailout loan initiation hypothesis (H3B), we posit that weaker firms are more likely to access the Fed facilities, especially after Lehman's collapse. We use measures of firm health, such as bank capital and ROA, prior to borrowing from the facilities. We also consider information from the TARP (Troubled Asset Repayment Program) regarding both usage and early repayment. Weaker banks are also identified as such by considering whether the firm later failed or was the recipient of a bailout. Firms that were closer to insolvency would have had fewer high quality assets to pledge to the Fed, and thus were more likely to post equity collateral when the Fed started accepting it in late 2008 (see Table A.4). Weak firms would not have borrowed as much from the FHLB if during the crisis the Fed programs were willing to take collateral on more lenient terms. This hypothesis is likely to be especially applicable after Lehman failed, as the Fed began to accept equity securities and junk bonds as collateral on September 14, 2008.

Banks that are close to insolvency may find the Fed lending programs particularly appealing if they are structured in such a way as to effectively provide a subsidy to weak banks. These banks would benefit from such policies regardless of their liability structure. That is, if the bank has borrowed extensively in short-term debt markets and is no longer able to roll over the debt due to credit risk concerns, it would be likely to borrow from the Fed if the lending programs were sufficiently lenient. Likewise, if it funded its assets without any short-term debt but was unable to fund its assets, due to deposit withdrawals or a sharp decline in equity capital, it would still borrow from the Fed under the right conditions. However, we posit that an insolvent bank with high reliance on short-term debt markets is more likely to borrow from the Fed as part of a bailout than a healthy bank with the same amount of short-term debt.

Finally, we analyze factors related to early repayment of DW and PDCF loans. Under the liquidity provision framework, when market funding is severely limited, institutions would be less likely to voluntarily prepay loans obtained from the DW or PDCF. However, as markets eased and the penalty rate rose well above market rates, prepaying LOLR loans might have become attractive, especially for institutions with sufficient access to capital markets. Under the bailout framework, factors other than easing of capital markets should be related to loan prepayments. Specifically:

H4 (Loan prepayment hypotheses)

H4A (Liquidity provision): *If the Fed liquidity facilities were effective in thawing frozen capital markets, financial institutions with high (low) exposure to capital markets should have been more (less) likely to prepay their loans.*

H4B (Bailout): *If the Fed liquidity facilities were used as substitutes for capital by undercapitalized institutions, financially weak institutions should have been more likely to prepay their loans when either their situations improved or the end of fiscal quarter approached.*

We test the liquidity provision prepayment hypothesis (H4A) by analyzing whether the amount of short-term debt and deposits affect the likelihood of prepayment. The rationale is that when credit conditions ease, banks with the highest exposure to the credit markets stand to benefit the most in prepaying above-market rate loans and, instead rely on short-term debt markets. The most important factor for the bailout loan prepayment hypothesis (H4B) is the creditworthiness of the firm, especially if it improves over time. We also consider the effect of disclosure in audited financial statements. The Fed loan data was secret prior to the Bloomberg FOIA lawsuit in 2011. However, if the amounts borrowed were large enough, banks may be required to disclose them in SEC filings, which might lead to a run on a bank, difficulty rolling over short-term debt, or a decline in the firm's stock price. Therefore, to avoid disclosure, banks would prefer to prepay loans immediately prior to the end of the fiscal reporting period. We investigate the fraction of banks that report outstanding Fed loans in their quarterly reports to determine if the stigma associated with undercapitalized banks motivates them to prepay the emergency loans.

1.2. Sample

Because we are interested in the effects of overall capital market disruptions on financial firms and the role of the LOLR in dealing with them, we restrict our sample to large firms. We screen for a set of potential borrowers that are publicly traded, have at least one quarter of Compustat and CRSP data available, and have assets of at least $1 billion (Berger et al. (2014)). Several foreign banks borrowed heavily from the Fed during the crisis but not all of them have data on Compustat or CRSP. In those cases, we search for their data on Global Compustat or collect data from their annual reports

and SEC filings.[9] Our total sample consists of 382 large commercial banks and 17 primary dealers with full Compustat and CRSP data. By construction, our sample uses data for the consolidated entity (including bank holding companies and bank subsidiaries).

Next, we identify firms that borrowed at least once during the crisis from at least one of the four facilities. We identify institutions accessing the DW, TAF, PDCF, and TSLF from the 3/31/2011 FOIA production by the Federal Reserve as discussed in the Appendix. Since the FOIA files only report the name of the institution and no other identifying information, we match the names manually. If the name of a borrower is not in CRSP or Compustat, we search for other identifying data in SEC filings and company websites to improve the matching process. We identify 213 banks that borrowed from at least one Fed facility and 169 non-users.

While data stop before June 2009 for 40 banks, we do not consider survivorship bias to be a problem among our sample of large commercial banks.[10] We obtain information regarding bank failures from the FDIC failed bank list and from a review of the financial press. We use failed banks' data for as long as they are available. We note that several European banks would not have survived as stand-alone entities absent a bailout from their local governments, but they were not shut down by their regulators, and are included in the sample throughout. In addition to acquisitions that cause a firm to exit the sample, acquisitions cause some sample firms to expand in size. This information comes from Securities Data Corporation (SDC).

Likewise, survivorship bias is negligible among the primary dealers. In early 2008, there were 20 primary dealers, including Bear Stearns, whose takeover by JPMorgan Chase was announced the day before the PDCF began. Countrywide, which was one of the few US dealers funded mainly with deposits, was terminated as a primary dealer in July 2008. Lehman is deleted from the New York Fed's list of primary dealers on September 22, 2008 and Bear Stearns, which merged with JPMorgan Chase, is not deleted from the list until October 2008. Merrill (which was acquired by Bank of America) continued to be a primary dealer until February 11, 2009. Only one new primary dealer, Jefferies, was added after the sample period started (in May 2009). Most of the primary dealers were investment banks or had large investment banking arms. Ten of the dealers were foreign and, in contrast to US dealers, often had large deposit-taking divisions that allowed them access to DW loans.

1.3. Sample characteristics

We begin by reporting the characteristics of loans and borrowers. Table 1, Panel A reports the size of each loan in the FOIA data for borrowers in our sample. The table also reports the maturity and interest rate for the 3614 loans together and by program. Panels B-E show that the DW and the TAF are the most popular programs, since they each account for nearly one-third of all lending activity. This is to be expected since the PDCF and TSLF are only available to the 17 primary dealers, whereas there are hundreds of commercial banks in our sample with access to the DW and TAF. Most of the DW and PDCF loans are overnight, whereas the TAF and TSLF loans, by design, have a maturity of a month or more. Given the short-term nature of the DW loans and the length of the crisis, the program could have provided well over a hundred thousand loans, but Panel A shows limited use of the programs.[11] The range of interest rates is wide, reflecting the decline in interest rates at the start of the crisis to the end of the sample period. While in other time periods the yield curve is generally upward sloping, in our sample period the FF rate either exceeds the one month rate, due to an inverted yield curve, or the rates are about the same (reflecting the long period of near zero rates).

The median TSLF loans and PDCF loans were larger than those made through the DW and TAF, partly reflecting the large relative size of the primary dealers that borrowed from the PDCF and TSLF. However, the distribution of DW loans is heavily skewed, as some large borrowers used the DW as well. For example, JPMorgan Chase borrowed $8.6 billion from the DW in late May 2008.

While the loan amounts are large in absolute terms, the median loan of $1.9 billion is about 12% of the (untabulated) median book value of short-term debt of the users in our sample. Some firms take out more than one loan at a time, but even considering the size of all new loans for a firm, the median amounts are comparable. Panel F of Table 1 shows the total amount of new loans taken out in all the programs on a given day by the same bank. The averages increase very slightly by this method of calculation, but the medians do not. Some banks borrowed again while other loans were still outstanding, so Panel G of Table 1 shows the average and median quantities owed by each bank on days when there is a loan outstanding. The averages and medians are larger still, but remain modest for most banks; for example, the median loan of $2.5 billion represents about 16% of the median book value of short-term debt of the users in our sample. The largest amount outstanding at any one point was nearly $100 billion, which was owed by Morgan Stanley.[12] Part of this sum reflects a $40.1 billion PDCF loan on September 29, 2008, the same day that Morgan Stanley received a $9 billion dollar equity injection from Mitsubishi UFJ Financial Group. With a balance sheet of slightly under a trillion dollars and $323 billion in short-term debt, the total Fed borrowing on that day amounted to about 10% and 30% of Morgan Stanley's assets and short-term debt, respectively. The largest single loan in the sample is a 4-day loan to Barclays on September 18, 2008 for $47.942 billion.[13]

The first two columns of Panel A of Table 2 compare the characteristics of commercial banks that used at least one of the Fed programs to non-users. While the financial characteristics in this table are measured as of 12/31/2007, the failed indicator and TARP-related variables are constant during the crisis and depend on outcomes during the crisis. The last column presents the characteristics of primary dealers.[14] The results indicate that users are larger firms, whether measured by average or median assets, and they rely more heavily on capital markets funding (they have fewer de-

[9] We include all US banks and investment banks that might have borrowed through one of the four programs. However, data limitations prevent us from creating a comparable sample for foreign banks. We include foreign banks that actually did borrow from one of the programs or which have available data on Compustat. We confirm that most large foreign banks are included in the sample: When we compare our sample to the American Bankers Association list of the 150 largest banks in the world by assets (December 2007 and June 2009 lists) only eight foreign banks are missing from our sample.

[10] For example, Washington Mutual is missing data after it goes bankrupt, and National City, Provident and Wachovia are acquired in 2008. ABN-Amro is acquired in mid-2007 and is the only acquisition that is not clearly related to losses in the crisis. We note that data for about 5% of users, 9% of light users, and 13% of non-users stop before the end of the sample period.

[11] Consistent with this finding, Berger, Black, Bouwman and Dlugosz (2015) find that the median number of times in a quarter that a commercial bank borrowed from the DW or TAF is zero.

[12] Bloomberg reported that Morgan Stanley borrowed $107 billion from the Fed. The Bloomberg figure includes borrowing using a single tranche repo. The Fed does not consider these repos to be emergency loans.

[13] As can be seen from Fig. 4, other firms borrowed more than $47.942 billion through the PDCF. The data in Fig. 1–6 represent total loan amount outstanding at a given point in time. In the case of Morgan Stanley, for example, it borrowed slightly over $61 billion from the PDCF through two loans on September 29, 2008.

[14] We do not report data on non-users for the PDCF or TSLF because that sample of primary dealers is small. We report data as of year-end 2007 except when missing data are replaced with figures from the next quarter.

Table 1
Descriptive statistics of loans from the federal reserve during 8/2007–6/2009.
This table reports distribution of loan characteristics. Included are all loans by institutions with data in Compustat (bank or industrial). DW stands for primary and secondary credit (Discount Window).

Panel A: All (N = 3614); Loan-specific	Ave	Min	Med	Max
Loan amount (million)	$4,472	$0.001	$1,900	$47,942
Interest rate	1.46%	0.10%	1.25%	5.75%
Maturity (days)	20	1	4	91
Panel B: DW (N = 1147); Loan-specific	**Ave**	**Min**	**Med**	**Max**
Loan amount (million)	$6,569	$0.001	$272	$35,000
Interest rate	1.78%	0.50%	1.75%	5.75%
Maturity (days)	6	1	1	91
Panel C: TAF (N = 1128); Loan-specific	**Ave**	**Min**	**Med**	**Max**
Loan amount (million)	$2,041	$5.000	$1,000	$15,000
Interest rate	1.56%	0.20%	1.39%	4.67%
Maturity (days)	45	28	28	84
Panel D: PDCF (N = 844); Loan-specific	**Ave**	**Min**	**Med**	**Max**
Loan amount (million)	$5,316	$10.000	$3,521	$47,942
Interest rate	1.47%	0.50%	1.25%	3.25%
Maturity (days)	2	28	28	28
Panel E: TSLF (N = 495); Loan-specific	**Ave**	**Min**	**Med**	**Max**
Loan amount (million)	$3,714	$10.000	$4,000	$15,000
Interest rate	0.44%	0.10%	0.25%	3.22%
Maturity (days)	28	8	29	32
Panel F: Total loan amount initiated on the same day; Bank-initiation day-specific (million)				
All loans (N = 3,379)	$4,783	$0.001	$1,825	$49,118
DW (N = 1,141)	$6,603	$0.001	$275	$35,000
TAF (N = 1,119)	$2,057	$5.000	$1,000	$15,000
PDCF (N = 844)	$5,316	$10.000	$3,521	$47,942
TSLF (N = 485)	$3,791	$10.000	$3,900	$15,000
Panel G: Total loan amount on calendar day; Bank-calendar day-specific				
All loans (N = 19,417)	$6,941	$0.001	$2,500	$97,292
DW (N = 2,414)	$5,023	$0.001	$1,950	$37,000
TAF (N = 16,748)	$4,679	$5.000	$2,000	$60,000
PDCF (N = 844)	$9,862	$10.000	$7,400	$61,292
TSLF (N = 3,360)	$10,697	$200.000	$8,977	$38,510

posits and more ST debt). These results are consistent with a description of the programs as providing liquidity during a crisis. Note that primary dealers have a much larger fraction of short-term debt than either group of commercial banks.

Focusing on FHLB borrowing, non-users borrowed a significantly larger fraction from FHLB banks, as measured by the median ratio of FHLB advances to total assets. This result is consistent with Ashcraft et al. (2010), who describe the FHLB as an effective LOLR. The higher usage of FHLB programs by non-users is also consistent with the view that Fed LOLR funds are relatively expensive (FLHB loans do not carry a penalty). One possible explanation for this relatively low usage of FHLB funding in our sample is that we include any bank that could use the Fed programs, including foreign banks that, like the primary dealers, were often not eligible for FHLB loans. Ashcraft et al. (2010) note that the all-in cost of a FHLB advance includes the cost of purchasing FHLB stock. Therefore, these data, which are from year-end 2007, may understate the fraction of FHLB loan users in the depths of the crisis if more banks that were not members before the crisis found that the cash outlay associated with FHLB stock was more than offset by the benefit of a low interest rate loan.

Table 2 Panel A also reports differences in credit quality between the user and non-user groups. Only two measures suggest that the commercial bank users are weaker banks: Their capital ratios are significantly lower at the beginning of the crisis (year-end 2007) and they are more likely to fail during the crisis when compared to non-users. About 8% of users failed, while only about 2% of non-users suffered the same fate. In contrast, the return on assets and (median) non-performing loans are not significantly different between users and non-users. The average of non-performing loans indicates that users have stronger balance sheets and their market-to-book ratios imply that they enjoy higher valuations. The insolvency index of users is not significantly different from the insolvency index of non-users. The Z-scores are also not significantly different between the two groups. Given that the characteristics are measured prior to the beginning of the crisis, it is not surprising that credit quality of user and non-user groups is similar.

Foreign firms account for 21% and 16% of users and non-users, respectively. While this difference is not significant, the availability of loans from their home governments suggests that 21% is a high fraction of foreign users.

We also report whether banks received capital from the TARP program. While TARP may have injected enough capital for banks to again tap private debt markets, the evidence in Table 2 suggests it allowed banks to borrow more from the Fed. The table indicates that users have significantly higher propensity to access TARP funding compared to non-users. Conditional on accessing TARP, users are about as likely as non-users to repay TARP quickly (i.e., before June 2009).

Table 2
Univariate analysis.
In panel A, number of observations (N) reflects number of institutions in the sample on 12/31/2007. *Users*/*Non-Users* are institutions with available data on bank Compustat and CRSP that have total assets larger than $1 billion as of 4Q 2006 and accessed/did not access fed facilties during the crisis. Insolvency index is a sum of the following indicator variables: Equity/TA is below median, ROA is negative, non-perf. Loans/TA are above median, MB is below median of the in-sample distribution, and Failed Indicator. For primary dealers, non-perf. Loans are not used in the calculation of the Insolvency Index. TARP related variables are reported based on a sample of U.S. institutions only. ***, **, * denotes statistical significance at the 1%, 5%, and 10% level, respectively, of test of means and medians against the *Users* group. Panels B–F shows characteristics of unique users and the average of the loans obtained from each of the facility in a particular calendar quarter.

Panel A: Q4 2007		Commercial banks:		Primary dealers (N = 17)
		Users (N = 213)	Non-Users (N = 169)	
Total assets (billion)	*Ave*	$226.3	$26.5***	$1,692.2
	Med	$7.8	$2.9***	$1,562.1
S-T debt / TA	*Ave*	8.39%	5.02%***	23.75%
	Med	7.06%	3.11%***	21.68%
FHLB advances / TA	*Ave*	3.84%	5.15%*	
	Med	0.67%	1.52%*	
Deposits / TA	*Ave*	66.21%	68.65%*	41.54%
	Med	68.62%	71.47%**	47.17%
Equity / TA	*Ave*	8.32%	9.52%***	4.03%
	Med	8.52%	8.78%**	3.17%
ROA	*Ave*	0.10%	0.07%	−0.06%
	Med	0.16%	0.17%	0.06%
Non-perf. Loans / Loans	*Ave*	1.24%	1.70%**	
	Med	0.88%	0.88%	
MB	*Ave*	1.04	1.02**	0.99
	Med	1.03	1.01**	1.00
Failed indicator	*Ave*	0.08	0.02**	0.35
Insolvency Index	*Ave*	1.69	1.69	1.67
	Med	2.00	2.00	2.00
Z score	*Ave*	101.33	85.67	50.37
	Med	65.32	60.18	34.46
Foreign indicator	*Ave*	0.21	0.16	0.47
Used TARP Indicator	*Ave*	0.42	0.31**	0.12
Repaid TARP before 6/2009 | Used TARP	*Ave*	0.40	0.30	1.00

		Pre-Bear		Post-Bear & Pre-Lehman		Post-Lehman			
		2007Q3	2007Q4	2008Q1	2008Q2	2008Q3	2008Q4	2009Q1	2009Q2
Panel B: Discount window	*N Users*	26	34	41	38	64	54	28	12
Total assets (million, q-1)	*Ave*	$713,093	$233,942	$505,473	$248,238	$373,797	$145,416	$350,768	$215,190
	Med	$181,583	$34,986	$59,849	$61,069	$33,673	$6,905	$16,320	$89,845
Loan amount (million)	*Ave*	$269	$134	$410	$552	$390	$1,311	$1,870	$2,561
	Med	$84	$3	$36	$105	$57	$19	$26	$8
All commercial banks	*N*	358	369	375	353	361	342	343	330
	Users %	7.3%	9.2%	10.9%	10.8%	17.7%	15.8%	8.2%	3.6%
Panel C: TAF	*N*		18	52	39	46	50	57	35
Total assets (million, q-1)	*Ave*		$548,494	$585,558	$496,848	$735,777	$457,343	$689,995	$438,455
	Med		$273,763	$224,330	$111,396	$300,671	$144,627	$253,525	$150,737
Loan amount (million)	*Ave*		$544	$1,252	$1,347	$1,525	$1,986	$2,215	$2,133
	Med		$199	$783	$500	$984	$1,000	$1,126	$1,075
All commercial banks	*N*		369	375	353	361	342	343	330
	Users %		4.9%	13.9%	11.0%	12.7%	14.6%	16.6%	10.6%
Panel D: PDCF	*N*			6	5	9	9	4	2
Total assets (million, q–1)	*Ave*			$1,879,932	$1,132,956	$1,871,473	$1,434,092	$1,536,673	$2,072,271
	Med			$2,311,542	$1,090,896	$1,775,670	$1,446,309	$1,774,704	$2,072,271
Loan amount (million)	*Ave*			$1,475	$4,241	$4,416	$6,934	$3,208	$2,648
	Med			$1,286	$1,704	$4,393	$5,911	$2,973	$2,648
All primary dealers	*N*			16	16	15	14	13	11
	Users %			37.5%	31.3%	60.0%	64.3%	30.8%	18.2%
Panel E: TSLF	*N*			11	11	14	10	11	2
Total assets (million, q-1)	*Ave*			$1,959,424	$1,562,790	$1,978,952	$1,560,768	$2,116,232	$1,373,934
	Med			$2,017,263	$1,217,613	$1,908,265	$1,514,146	$1,938,470	$1,373,934
Loan amount (million)	*Ave*			$4,881	$3,760	$3,342	$4,032	$2,802	$3,700
	Med			$3,000	$3,500	$3,820	$4,212	$2,633	$3,700
All primary dealers	*N*			16	16	15	14	13	11
	Users %			68.8%	68.8%	93.3%	71.4%	84.6%	18.2%
Panel F: All	*N*			79	66	91	86	76	43
Total assets (million, q-1)	*Ave*			$505,906	$436,916	$496,436	$325,750	$567,135	$397,977
	Med			$142,543	$106,444	$126,649	$33,572	$205,656	$142,144
Loan amount (million)	*Ave*			$1,128	$1,398	$1,158	$2,035	$2,243	$1,950
	Med			$354	$410	$420	$299	$902	$1,000

Finally, we consider the characteristics of the primary dealers. Because there are only 17 firms in the dealer sample, we do not compare users to non-users with t-statistics. Most primary dealers are users at some point in the sample. The dealers are large firms that rely heavily on short-term debt markets. On average, short-term debt accounts for 24% of assets, while deposits are only 42% of assets. Thus, while both users and non-users in the set of commercial banks had the capacity to shift from capital markets borrowing to insured deposits after the Lehman failure, the primary dealers had quite limited access to these funds. Not shown, the fraction of assets funded by deposits is even lower for U.S. primary dealers, which have a greater focus on investment banking than their European counterparts. Equity capital, ROA, and market-to-book are all low compared to the commercial banks in our sample. The insolvency index is only slightly lower than that of the commercial banks, reflecting the fact that the index uses only four measures of strength instead of the five used in the commercial bank index (non-performing loans are not reported for these firms) and that a large proportion, 35%, of primary dealers failed or were merged due to solvency concerns during the crisis. Furthermore, their Z-scores are, on average, lower when compared to the commercial banks in our sample. Two (12%) of the primary dealers accessed TARP and both of the firms repaid TARP before June 2009.

2. Results

2.1. Tests of the market funding replacement hypotheses (H1)

Our first test of the market funding replacement hypothesis (H1) is conducted in Table 2 Panels B-F, which report quarterly data on the use of each of the four Fed liquidity facilities. H1 predicts that the number of financial firms using the discount window and other emergency lending programs would have been high during the crisis and that the money borrowed would have been a large fraction of their assets. Table 2 does not support H1, as it shows a strikingly small number of users. The bottom rows of Table 2, Panels B and C report the number of large commercial banks that could have used the DW and TAF during this period, which was 375 at the peak (Q1 2008). Only a small fraction of the banks accessed either of them during any of the eight quarters in the sample period. The quarter with the highest fraction of DW users (the one when Lehman filed Chapter 11) saw less than 18% participation by commercial banks. The low number of DW borrowers does not owe to a substitution into TAF, since that program's popularity was greatest in Q1 2009, and Q3 2008 saw only the slightest increase in popularity from the previous quarter. Given the high expense of DW loans, the liquidity framework predicts that the TAF will be more popular, especially before Lehman when TAF auctions may have been undersubscribed or less competitive. Counter to H1A and H2A, DW loans were often as popular as TAF loans. Only at the end of the sample period, when conditions in markets were more settled, does the relatively low price of TAF funding appear to increase its popularity markedly over the discount window.

The funds borrowed from DW and TAF, while large in absolute dollar amounts in late 2008 and early 2009, were a small fraction of the funds required to maintain these banks' portfolios. The median DW loan amount in the most active quarter, Q3 2008, was only $57 million, or approximately 0.17% of the banks' typical assets. Measured by averages, the amount borrowed was even smaller. Borrowing via the TAF program was greater, but the median and average in Q1 2009 were still less than 1% of assets of the banks that received the funds.

Table 2, Panel C shows that users of the TAF program are larger banks than DW borrowers. The average assets of a TAF borrower always exceeds $400 billion while the average DW borrower has assets as low as $145 billion in Q4 2008. In each of the eight quarters, the DW median asset size is much smaller than the median TAF size. This difference in size may reflect the advantage that larger banks have over smaller banks in preparing a competitive bid as well as the fact that the TAF has a minimum bid amount of $5 million. The minimum TAF bid amount is higher than the median amount borrowed through the DW in Q4 2007 and not much lower than the figure for 2009Q2.

The larger average assets of the TAF users may also reflect the fact that larger, capital markets-oriented firms were more likely to have suffered losses in the subprime crisis, making it more likely that they would seek support from the emergency programs. Consistent with this perspective, Table 2, Panel D reports a much higher fraction of PDCF usage by primary dealers than DW or TAF usage by commercial banks, suggesting that the new emergency facility aimed at primary dealers was much more effective than the DW. As Panel E shows, the TSLF attracted wide participation throughout the crisis, with nearly all primary dealers accessing the facility in Q3 2008. The greater participation and higher loan amounts in the TSLF compared to the PDCF suggests that the absence of penalty rates aided the popularity of this new auction program as well. However, we note that the amounts borrowed by primary dealers in either program were very small in comparison to their trillion dollar balance sheets.

The number of users increased among all four programs after Lehman declared bankruptcy, with the sharpest increase in the PDCF. The liquidity framework predicts that borrowing would be widespread in the crisis, but as Panel F shows, at most only 91 borrowers, or less than a quarter of the banks, used any facility in any one quarter. The average amounts borrowed in the post-Lehman period relative to the pre-Lehman period are higher for the DW and TAF, but the median loan sizes for DW are still relatively small and not meaningfully different from median DW loan sizes in the earlier periods. We note larger PDCF loans in the post-Lehman period, especially in Q3 and Q4, but TSLF loan sizes do not show dramatic changes. Thus, Panel F shows that the median amount borrowed in all four programs only jumps a small amount after Lehman fails. Finally, we note that the use of all four programs dropped off dramatically by the end of the sample period.

We present further univariate analyses of the market funding replacement hypotheses (H1) in Figs. 1–6. Fig. 1 shows the amount outstanding owed by all firms, including small banks and thrifts that are not in our sample. Across all Fed programs combined, the aggregate outstanding never exceeds $800 billion, and indeed, the debt rarely reaches $750 billion at any point in time in the crisis. To put this amount of borrowing in perspective, we consider the total amount of borrowing from all four Fed facilities and from the FHLB by firms in our sample relative to the total amount of their short-term debt (Fig. 2). The figure graphs the aggregate amount of short-term debt reported by the sample firms in Compustat, which does not include FHLB advances but which does include Fed borrowing if balances are still outstanding at quarter-end. H1A states that Fed borrowing should replace a substantial portion of short-term borrowing if the Fed programs mainly worked to provide liquidity to frozen markets. Fig. 2 shows that even when the markets were most stressed, they continued to supply the vast majority of these large firms' short-term debt needs. FHLB advances provided relief from debt market stress to banks during the crisis that was comparable to the relief provided by the Fed programs. The four programs were not often used as substitutes for short-term debt funding during the crisis period and the amounts borrowed from them never exceeded 15% of short-term debt. Therefore, H1A would only be accepted if 15% is considered a large enough figure to count as substantial relief from frozen debt markets.

Fig. 2 indicates that total short-term capital markets debt declined over the period. The total outstanding dropped from about

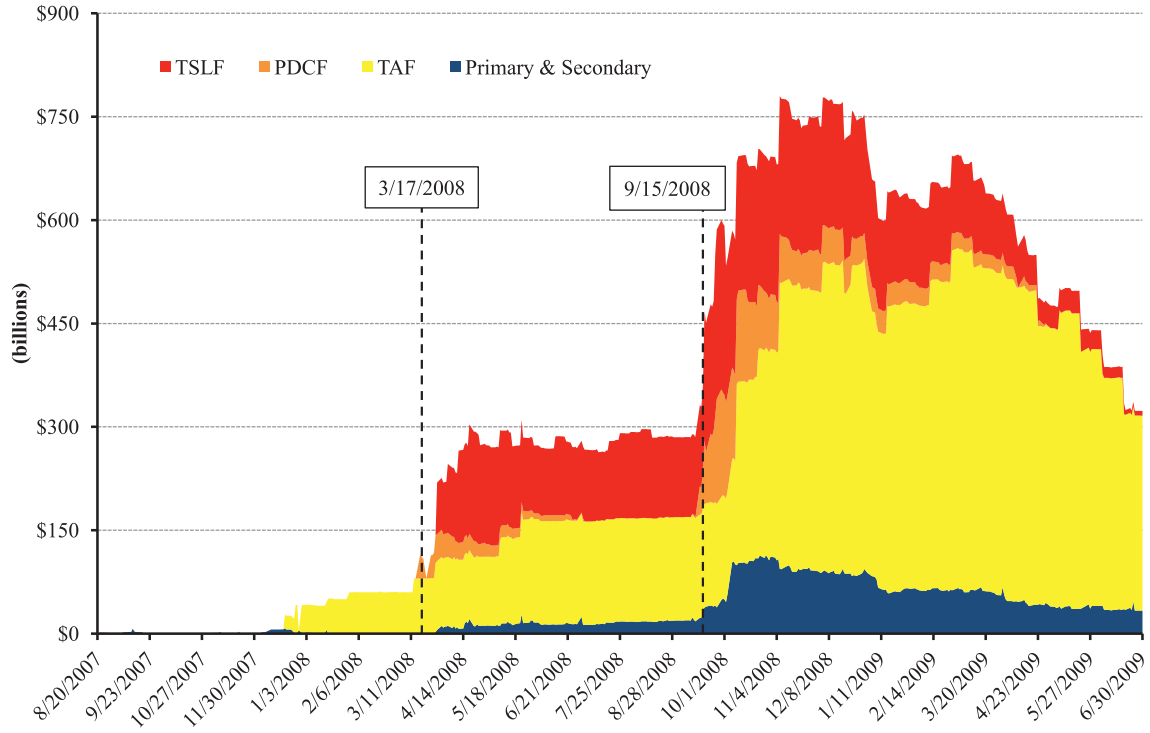


Fig. 1. Total primary and secondary credit, PDCF, TAF, and TSLF borrowing for financial institutions: 8/20/2007 - 6/30/2009. Source: Federal Reserve (FOIA 3/31/2011).

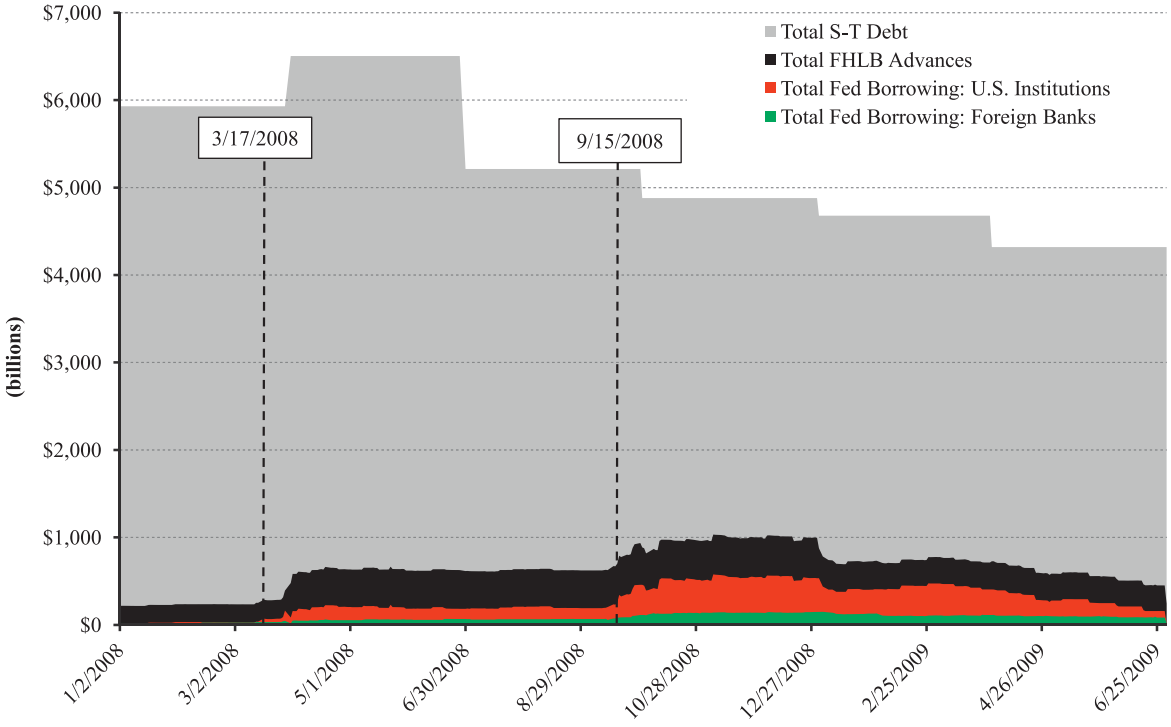


Fig. 2. Fed borrowing, S-T Debt and FHLB advances for sample financial institutions: 1/2/2008–6/30/2009. Source: Federal reserve (FOIA 3/31/2011) and Compustat.

$6.5 trillion at in Q1 of 2008 to about $4.3 trillion in 2009. This decline does not reflect deleveraging by banks, since the average leverage ratio increases in nearly every quarter in the sample. Rather, the decline in short-term debt generally reflects an increase in the use of deposits, consistent with the evidence in Boyson et al. (2014).

Figs. 3–6 graphs the usage of each program by the type of borrowing bank. Fig. 3 shows that DW borrowing was very light until late March 2008 (after Bear Stearns fails). As a comparison, Furfine (2001) shows that borrowing from a Fed facility set up for Y2K problems reached $1.187 billion on December 29, 1999. Only about a third of the days between August 20, 2007 and April 1, 2008 had DW loans outstanding of more than $1.187 billion and several of those days were related to the Fed's request of several large banks that they "test borrow" in August 2007. Thus, DW borrowing in the first nine months of the crisis sug-

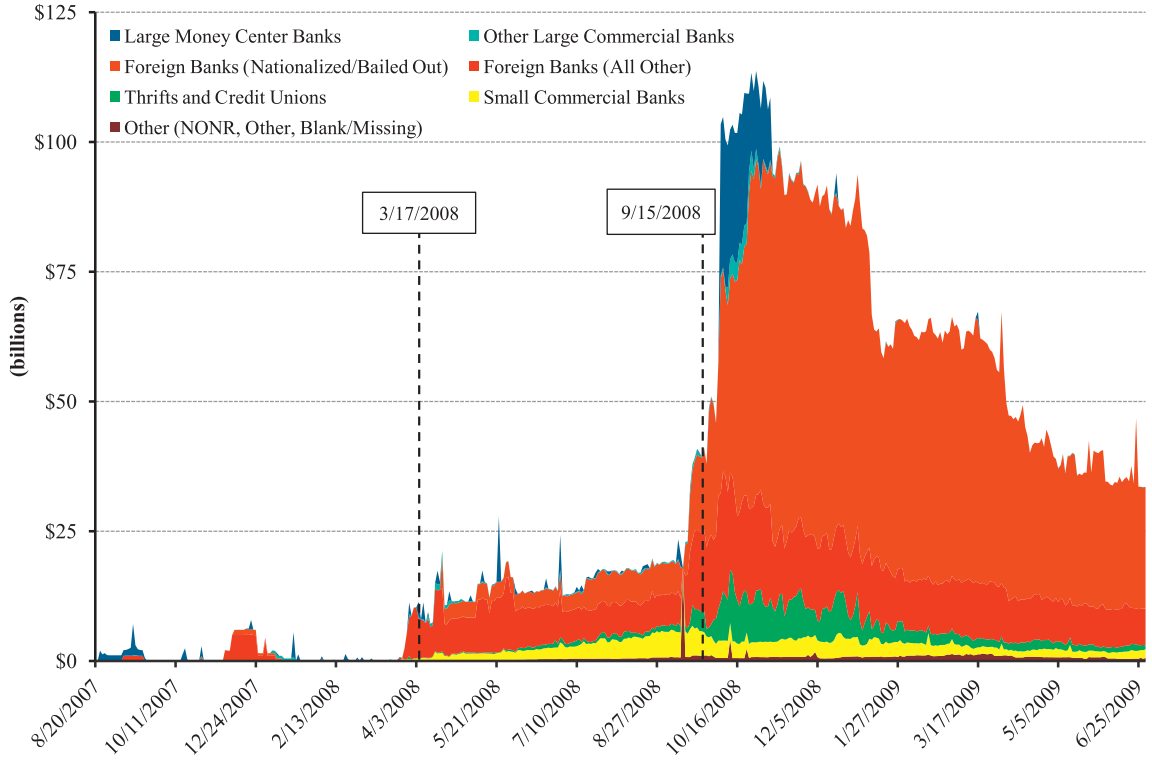


Fig. 3. Total primary and secondary credit borrowing for financial institutions: 8/20/2007–6/30/2009. Source: Federal reserve (FOIA 3/31/2011).

gested a situation that was only marginally worse than the Y2K scare.

Fig. 3 also indicates that the majority of the DW loans went to foreign banks in weak financial health[15]. These banks accounted for the vast majority of DW borrowing after Lehman and a large portion of it occurred in the months leading up to Lehman's Chapter 11 filing, despite their ability to access LOLR loans in foreign countries[16]. By the time the foreign bank borrowing reached its peak in late 2008, many of these European banks had already received bailouts from their governments. In contrast, U.S. banks that were the most likely to be affected by frozen debt markets, the large money center banks (LMCBs), scarcely approached the DW before October 2008 and quickly repaid the loans when they did. LMCBs borrowed less than $30 billion from the discount window at any point in time, accounting for a small fraction of total DW borrowing on any given day.

Fig. 4 shows that LMCBs borrowed much more from the TAF program than through DW borrowing (about four times as much at the peak in late 2008). This differential suggests that the auction programs helped alleviate the stigma associated with DW loans. However, LMCBs still accounted for less than half of all borrowing in the TAF program. The fraction of LMCB debt in Fig. 4 is notably small before October 2008 and while it increased after Lehman, these banks' total TAF borrowing never exceeded $200 billion. Recall from Table 2, Panel C that the average TAF borrower assets are well over $400 billion throughout the sample period, so total TAF borrowing would not have substituted total borrowing for even one bank on average.

One explanation for the low LMCB borrowing is that banks obtained a large portion of their funding from deposits, which is a stable, even increasing, source of funds in a crisis (Gatev and Strahan, (2006); Gatev et al., (2009); Cornett et al., (2011), and Boyson et al., (2014)). In untabulated results, we note that deposits for users increased by almost $1 trillion between 2Q 2007 and 4Q 2008. In contrast, some primary dealers may not have been able to increase deposits to offset the loss of short-term debt funding, especially the U.S. dealers, which typically do not own retail banks. Consistent with this argument, the two facilities available to primary dealers (PDCF and TSLF) have the highest participation rates of the Fed programs, suggesting that the use of Fed programs increases with illiquidity in capital markets for primary dealers. Fig. 5 shows that 18 dealers used the PDCF at some point in the crisis and only HSBC and Greenwich/RBS never used the facility[17].While Fig. 5 shows a large spike in usage right after Lehman declares bankruptcy, as nearly all dealers at that point borrowed from PDCF (including Lehman after its failure), the total amount lent through the PDCF peaked at less than $160 billion. Fig. 6 also shows heavy borrowing by most of the 18 dealers after September 15, 2008 (also including Lehman), but the two firms that did not use the TSLF were Daiwa and Mizuho.

Overall, based on the univariate analyses of the market funding replacement hypotheses in Table 2 and Figs. 1–6, we find ev-

[15] These institutions include Bank of Scotland (bailed out by the UK government on 10/13/2008), Depfa (bailed out by the German government on 10/6/2008), Dexia (bailed out by the Belgian government on 1/19/2009), Fortis (partially nationalized by Benelux on 9/28/2008), and Royal Bank of Scotland (recapitalized by the UK government). The corresponding loan amounts ranged from $5 billion to $37 billion and the loans were rolled over for periods ranging from one day to 15 months (Dexia). The timing of the loans coincided with the dates of their bailouts or recapitalizations/ nationalizations.

[16] A possible explanation for this heavy borrowing by foreign banks is a shortage of dollar funding in foreign markets. We do not find this to be a viable explanation. In untabulated results, we assess this conjecture by analyzing the amount of swap lines made available by the Fed to foreign LOLRs. Table A.4 indicates that following Lehman bankruptcy, the swap lines increased from about $62 billion to $635 billion. Hence, at the time that the Fed entered in swap line agreements with foreign LOLRs, foreign institutions substantially increased their DW borrowing.

[17] Note that Figs. 5 and 6 show borrowing for all 20 primary dealers, whereas Table 2 includes firms with data in Compustat and CRSP.

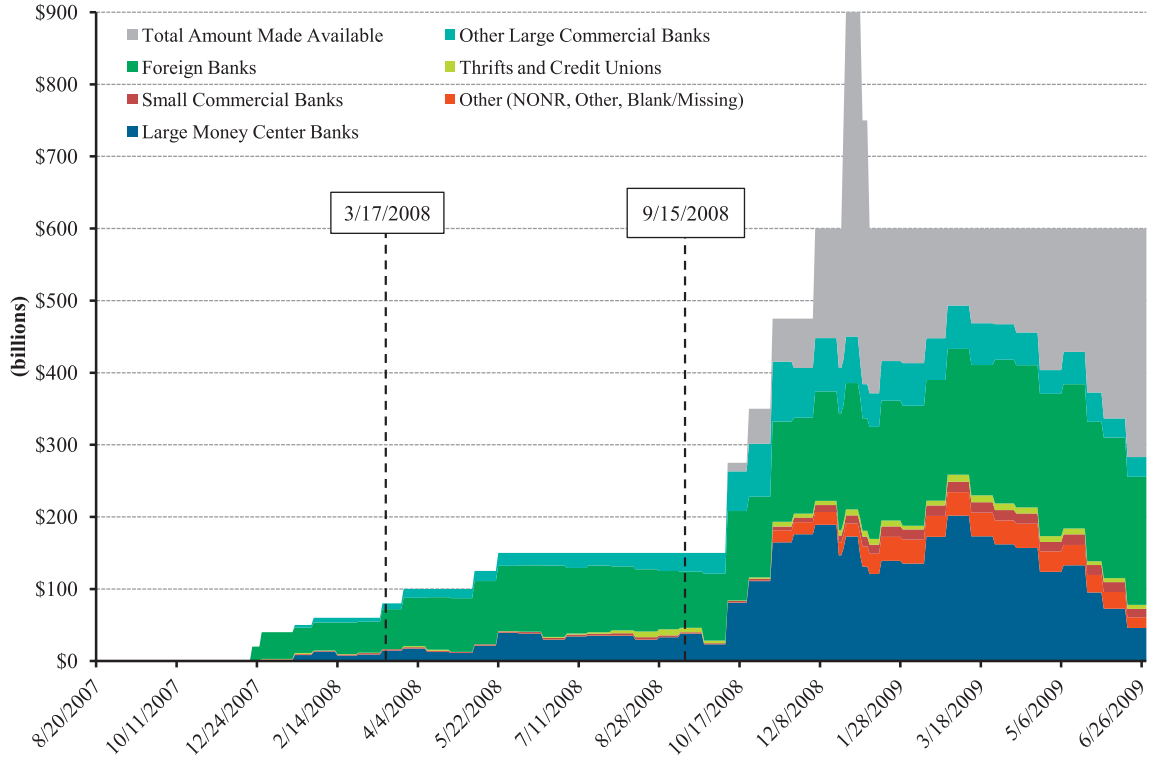


Fig. 4. Total TAF borrowing and total amount made available for financial institutions: 8/20/2007–6/30/2009. Source: Federal reserve (FOIA 3/31/2011).

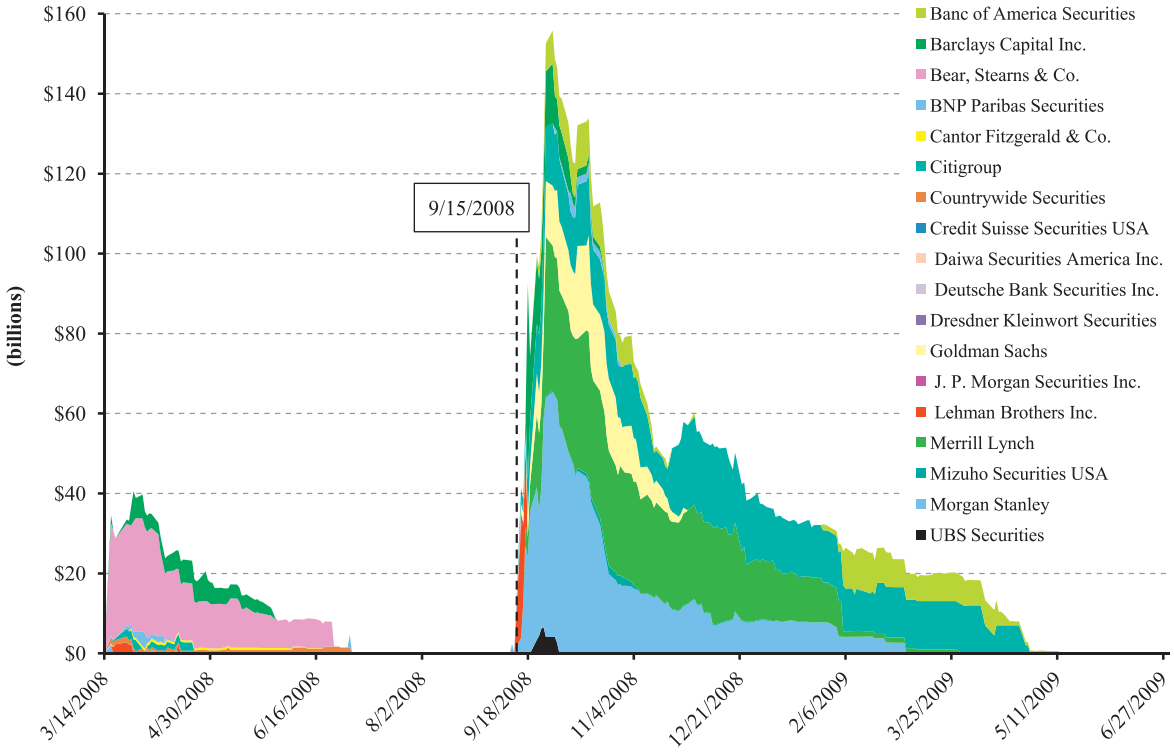
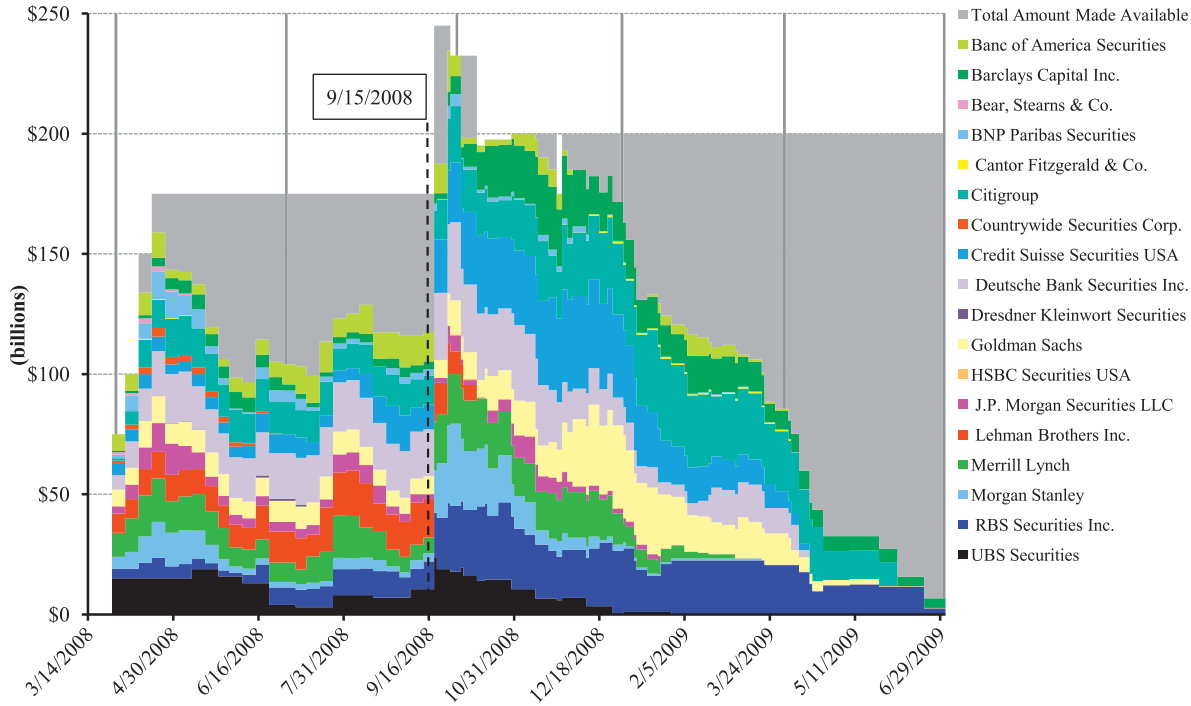


Fig. 5. Total PDCF borrowing for financial institutions: 3/14/2008–6/30/2009. Source: Federal rReserve (FOIA 3/31/2011).

idence that generally rejects H1A. The large amount of borrowing by failed European banks from the TAF and DW provide support for the bailout hypotheses of H1B and H2B. Likewise, the fact that Lehman borrowed through the PDCF and TSLF after it had already filed for bankruptcy indicates that the programs were not strictly used for liquidity provision.

2.2. Tests of pervasiveness of use hypotheses (H2)

We next analyze the pervasiveness of use hypotheses (H2) by testing whether participation in the Fed programs was widespread. Table 3 reports the average and median Herfindahl index (HHI) of loan amounts for each program (Panel A) and the index scaled by



Note: Calendar quarter ends are marked with vertical gridlines.

Fig. 6. Total TSLF borrowing for financial institutions: 3/14/2008–6/30/2009. Source: Federal reserve (FOIA 3/31/2011).

Table 3
Statistical tests of changes in loan concentration.
This table reports the average and median concentration of loans in DW, TAF, PDCF, and TSLF for periods preceding and following the Lehman bankruptcy. The concentration is measured as the Herfindahl index (HHI) of loans taken out on the same day (Panel A) and as the HHI of loans taken out on the same day scaled by the HHI of total assets of total assets of firms in the sample eligible to borrow from a particular program. ***, **, * denotes statistical significance at the 1%, 5%, and 10% level, respectively, of test of means and medians.

		Pre-Lehman	Post-Lehman (9/16/08 - 12/31/08)
Panel A: HHI loans			
Discount window	*Ave*	0.776	0.497***
	Med	0.867	0.491***
TAF	*Ave*	0.058	0.027***
	Med	0.053	0.032***
PDCF	*Ave*	0.635	0.292***
	Med	0.608	0.290***
TSLF	*Ave*	0.094	0.152***
	Med	0.082	0.148***
Panel B: HHI loans normalized by size HHI			
Discount window	*Ave*	25.155	16.117***
	Med	28.411	15.985***
TAF	*Ave*	2.724	1.310***‘
	Med	2.511	1.639***‘
PDCF	*Ave*	8.505	4.193***
	Med	7.956	4.197***
TSLF	*Ave*	1.656	2.604***
	Med	1.586	2.626***

HHI of the size of the firms in the sample eligible to borrow from a particular sample (Panel B). Thus, a firm that borrows 10% of the loans would be borrowing its “fair share” of Fed debt if it also accounted for 10% of the overall bank assets in our sample. In that case the normalized value would equal 1. A number larger than one indicates the firm is borrowing more than would be expected given its size. We test for differences in the HHIs from the pre- to post-Lehman bankruptcy periods to test H2. For DW and PDCF, we calculate the HHI based on the share of the loans initiated on the same day. For TAF and TSLF, the share is based on the size of the auction offering, so that if a particular auction was undersubscribed, the HHI would be low[18]. The HHI values are, by design,

[18] Note the gray areas in Figs. 3 and 5, which show the size of the available funds in the auctions. We note that TAF auctions in October to December 2008 were undersubscribed after the Fed increased the auction size to $150 billion. The TSLF was undersubscribed in November 2008 even though the Fed did not change its size.

capped for the TAF and TSLF, as their rules limit funding to any one firm[19].

Prior to Lehman's bankruptcy, participation in the Fed programs was often concentrated among a handful of firms. Panel A shows that DW and PDCF borrowing was often done by only one or two firms since the average HHI is close to one. Panel B shows that the scaled HHI is substantially higher than one.

If borrowing increased sharply in late 2008 because debt markets froze after Lehman, we would expect the HHI values to decline after September 15. Table 3 shows that the HHI as well as the scaled HHI do indeed decline for DW, PDCF, and TAF at this time. Therefore, the Lehman event leads to a statistically significant increase in pervasiveness of the use of the three facilities, which is consistent with H2A. For TAF, we further note that the post-Lehman concentrations are consistent with pervasive use and supportive of H2A. However, while the declines in the loan concentrations are significant for DW and PDCF, the absolute levels of the HHI indicate that the use of the programs remained concentrated even in the post-Lehman period. For example, for DW (PDCF), the HHI value of 0.497 (0.292) indicates that as few as two (three) institutions borrowed comparable amounts on the same day.

The use of TSLF is characterized by increasing HHI values, implying that TSLF borrowing becomes more concentrated after the Lehman bankruptcy. This owes only a bit to Lehman's lack of participation in the auctions after its bankruptcy (an increase of about 0.005 in the HHI, or less than 10% of the increase in the average HHI of TSLF loans)[20]. The higher concentration of borrowing in this program reflects the relatively low usage by Goldman Sachs, JP-Morgan, Bank of America and several foreign dealers. Overall, for DW, TAF, and PDCF, the evidence shows significant declines in concentration in the post-Lehman period, which is supportive of the liquidity provision of the pervasiveness of use hypothesis (H2A), while for TSLF, the evidence is supportive of the bailout hypothesis (H2B). We also note that for all but the TAF, the usage of the programs remains concentrated in the post-Lehman period, as indicated by the high levels of HHI.

2.3. Tests of the loan initiation hypotheses (H3)

The liquidity provision hypothesis H3A predicts that repo market borrowing will be replaced to a large extent by Fed emergency loans. Indeed, the Fed's purpose in creating the TSLF was to promote the exchange of illiquid securities owned by dealers for Treasuries in the Fed's portfolio. This would allow primary dealers to use the more desirable Treasury securities in the repo market (Fleming et al., 2009). In Table 4, we examine the use of collateral pledged for PDCF loans over the course of the crisis.[21] Copeland et al. (2010) show that the majority of collateral posted in the repo market is either Treasury or MBS bonds, with only about 6% of repo borrowing backed by corporate bonds and even less by equity.

At the onset of the crisis, PDCF collateral was fairly similar to tri-party repo collateral, although Treasury bond collateral was rarely posted. After Lehman, the mix of assets changes significantly and becomes more concentrated. In the first half of 2008, corporate market instruments, agency MBS, other MBS, municipal securities, and ABS account for 16% to 24% of the collateral pledged. Furthermore, by Fed collateral rules, none of the pledged collateral is rated BB or lower. Post-Lehman the most common types of collateral are corporate bonds, 48%, followed by equity, 25%. More than half of the pledged collateral is rated BB or lower. Reflecting the Fed's post September 14, 2008 broadened guidelines allowing loans backed by lower-rated instruments, there is a sharp decrease in agency MBS, other MBS, and ABS collateral usage in the PDCF. If debt markets froze as investors became more concerned about toxic (non-agency) mortgage-backed securities during September 2008, the increase in PDCF usage in late 2008 should have been accompanied by a higher fraction of (non-agency) MBS with the easing of the Fed's credit rating restrictions on September 14, 2008. In untabulated data, we find that the dollar amount of non-agency MBS collateral falls in Q3 2008 and PDCF borrowing shifts to junk bonds and equities. That is, the decline in non-agency MBS collateral is inconsistent with Fed programs substituting for frozen repo markets, as primary dealers rarely used non-agency MBS collateral at the Fed window post-Lehman. Further, the larger fraction of equity collateral and junk bonds in late 2008 suggests these banks were short on unencumbered, high quality collateral, as predicted by the bailout hypothesis H3B.

Another possible explanation for the decline in usage of MBS as collateral for the PDCF is the decline in the FF rate during Q4 2008. The Fed's summary of its open market operations in 2008 indicates that the conditions in late 2008 were extreme, owing to high excess reserves and high demand for Treasuries.[22] These include unusually high activity with reverse repos in September and a very high fraction of single-tranche RPs based on MBS. A primary dealer might have found it more cost effective to use its investment-grade MBS in transactions with the Fed's trading desk than with the PDCF.

Next, we use a multivariate analysis of the factors related to Fed borrowing and examine how they changed around the time of Lehman bankruptcy. Specifically, we estimate a hazard function of the conditional probability of borrowing that allows for multiple events (see Andersen and Gill, 1982), where each event is defined as a new loan from the Fed. In Tables 5–8, we present estimates of such hazard functions with multiple events, where each table presents separate estimates for DW, TAF PDCF, and TSLF borrowing. The dependent variable in these models is set to one each time a user borrows from the program and zero otherwise. We estimate the coefficients over the pre- and post-Lehman periods for each program, and then test whether differences in the coefficients support the liquidity provision or bailout loan initiation hypotheses. For DW and TAF, we also perform the analysis using the sample of domestic banks to assess whether foreign banks' borrowing is meaningfully different from US banks' borrowing.

Table 5 Panel A shows the hazard function estimates for DW loan initiations for all institutions in our sample, while Panel B reports results for US institutions only. The first five models use data for the base period prior to the Lehman bankruptcy. Focusing on the variables in these five models that are related to the liquidity provision framework, the coefficients on ST debt are positive and significant in all but model (3). This result indicates that, early in the crisis, banks that rely more on wholesale funding were more likely to borrow from the Fed. The coefficient on deposits is significantly negative in models (2), (3), and (5), indicating that banks that rely more on wholesale funding (have fewer deposits) are more likely to borrow from the DW. These results support the liquidity framework. In contrast, the significant negative coefficient on FHLB advances in the pre-crisis period suggests that the program was less successful than it could have been in providing

[19] For the TAF the limit is 10% and for the TSLF it is 20%. If each TAF auction had exactly 10 recipients, the HH1 would be $10*0.1^2 = 0.1$. If each TSLF auction had exactly 5 winners its HHI would be $5*0.2^2 = 0.2$. Furthermore, the PDCF and TSLF programs are limited to no more than 20 participants (the number of primary dealers), so if all primary dealers participate in the auction, the HHI cannot fall below 0.05.

[20] Assuming that 15 primary dealers, i.e. one extra dealer, would participate in the Q3 2008 auctions.

[21] The FOIA data only includes collateral information for PDCF loans.

[22] See the full report at https://www.newyorkfed.org/medialibrary/media/markets/omo/omo2008.pdf.

Table 4
Percent of type of collateral pledged for PDCF loans over time.
This table reports the fraction of collateral pledged for PDCF loans for institutions in our sample. The collateral information is obtained from the Federal Reserve website on PDCF (http://www.federalreserve.gov/newsevents/reform_pdcf.htm). Total reports number of observations, average, and median for the Pre-Lehman period. ***, **, and * indicates that the averages/medians for a Post-Lehman quarter and the entire Pre-Lehman period are significantly different at the 1%, 5%, and 10%, respectively.

Type of collateral		Pre-Lehman			Post-Lehman			
		2008Q1	2008Q2	Total	2008Q3	2008Q4	2009Q1	2009Q2
	N	154	14	168	202	286	140	48
US treasury / agency	*Ave*	1.56%	0.00%	1.43%	0.92%	0.87%	0.22%	0.27%
	Med	0.00%	0.00%	0.00%	0.00%***	0.00%***	0.00%***	0.08%***
MBS agency	*Ave*	20.93%	0.32%	19.21%	4.98%***	0.00%***	0.00%***	0.00%***
	Med	0.00%	0.00%	0.00%	0.00%***	0.00%***	0.00%***	0.00%***
MBS other	*Ave*	21.25%	3.10%	19.74%	3.88%***	3.82%***	6.45%***	5.09%***
	Med	16.06%	0.00%	7.31%	0.45%***	2.82%***	0.86%***	0.57%*
ABS	*Ave*	17.26%	9.93%	16.65%	5.91%***	4.21%***	5.87%***	9.16%***
	Med	12.61%	0.24%	12.20%	1.10%***	4.39%***	1.75%***	2.35%
Municipal securities	*Ave*	12.78%	86.56%	18.93%	4.21%***	17.34%	0.39%***	6.24%***
	Med	0.01%	99.12%	0.02%	0.05%	0.03%***	0.01%	1.27%***
Corporate market instruments	*Ave*	26.23%	0.09%	24.05%	48.09%***	48.46%***	56.13%***	49.14%***
	Med	0.86%	0.00%	0.62%	45.44%***	35.80%***	58.48%***	51.40%***
Equity securities	*Ave*	0.00%	0.00%	0.00%	25.02%***	16.02%***	15.94%***	17.52%***
	Med	0.00%	0.00%	0.00%	20.73%***	13.92%***	15.35%***	13.70%***
International & loans & other	*Ave*	0.00%	0.00%	0.00%	6.98%***	9.26%***	15.00%***	12.57%***
	Med	0.00%	0.00%	0.00%	1.80%***	5.56%***	8.87%***	9.58%***
Rated BB and lower	*Ave*	0.00%	0.00%	0.00%	52.82%***	31.42%***	35.75%***	53.83%***
	Med	0.00%	0.00%	0.00%	50.98%***	35.73%***	39.56%***	54.85%***

liquidity because DW debt is expensive. However, the size of the penalty over the FF rate is not significant.

The bailout framework draws little support during the pre-Lehman bankruptcy period (models (1)–(5)). Model (1) shows that banks with higher capital, higher ROA, higher market-to-book and banks that did not fail during the crisis were more likely to borrow from the Fed before the crisis. These metrics of creditworthiness during the pre-Lehman bankruptcy period indicate that DW users are healthier. Only the coefficient on non-performing loans suggests otherwise. Consistent with these results, aggregating the five individual measures into an insolvency index yields a significant negative coefficient in model (2), indicating that insolvent banks are less likely to use DW during the pre-Lehman bankruptcy period.

The conclusion that Table 5 Panel A supports the liquidity hypothesis H3A and rejects H3B is less clear when considering the specifications of models (3) and (5). In these models, we include an interaction term of the insolvency index or the Z-score with ST debt, deposits, and FHLB advances. These interactions allow us to test H3B. We find that the role of capital markets is smaller in model (3) once the interaction variables are included. ST debt is no longer a factor in the hazard model for DW borrowing, as its coefficient drops sharply and is no longer significant. The coefficient on the interaction of the insolvency index with ST debt is significant and has a positive sign, implying a higher likelihood of DW loan for insolvent banks with high levels of ST debt. While this finding is consistent with H3B, we note that the effect of ST debt is small even for the insolvent firms. This reflects the fact that the insolvency coefficient in model (3) is significant and considerably more negative than in model (2). Combining the coefficients of the two variables, the effect of ST debt appears small relative to the effect of insolvency index. To see this, consider a bank with the insolvency index equal to zero: based on model (3), there is no relation between ST debt and the likelihood of borrowing from the Fed, which contradicts H3A. Consider another fairly healthy bank, with an insolvency index of 1 and the average amount of ST debt in the pre-Lehman period (6.6%): the net predicted effect of insolvency and ST debt would be negative 0.82 ($=-0.94^*1+1.84^*1^*0.066$). For a bank with the highest insolvency index of 5, the net predicted effect of insolvency and ST debt is negative 4.09 ($=-0.94^*5+1.84^*5^*0.066$). Hence, the effect of the positive coefficient on the interaction of the insolvency index and ST debt is dwarfed by the effect of the coefficient on the insolvency index. This result also suggests that the positive coefficients on ST debt in models (1) and (2) are driven by the insolvent banks in the sample. Overall, the results in model (3) are inconsistent with the liquidity provision hypothesis H3A.

In the pre-Lehman period, insolvent banks are less likely to borrow no matter how they fund themselves, be it by deposits or FHLB advances. In model (3), for banks with an insolvency index equal to zero, the net effect of higher deposits is a lower probability of borrowing from the Fed. But because the insolvency index is never negative, the negative 0.94 coefficient of the insolvency index in model (3) outweighs the effects of the interactions. For example, for banks with the maximum insolvency index and the pre-crisis average deposit value (69.5%), the net effect of the deposit coefficient and the interaction coefficient is positive 1.08 ($=-3.25^*0.695+0.96^*0.695^*5$). However, the insolvency effect is so large ($-4.7=$-0.94*5) that the overall impact of an insolvency value of 5 is less borrowing in the pre-Lehman period. We note similar results for FHLB borrowing in model (3). Given the average FHLB borrowing of 5.6% during the early time period, a bank with an insolvency index of 5 would have a positive interaction effect of 0.29 ($=1.04^*0.056^*5$) that nearly offsets the direct FHLB advances effect of −0.35 ($=-6.20^*0.056$). As is the case for deposits, neither effect related to FHLB advances is very large when compared to the −4.70 impact from the insolvency index alone. Thus, whether the bank has slightly more deposits, FHLB advances, or ST debt, an insolvency index of 5 swamps all interaction effects and leads to less borrowing in the pre-Lehman period.

In models (4) and (5) we measure health with the Z-score. This variable is insignificant in model (4). Model (5) reports the results for regressions with interactions of Z-score with ST debt, deposits, and FHLB. With the exception of ST debt, the results are generally consistent with our prior findings. For example, for banks with low Z-score (less creditworthy), the overall relation between deposits and the likelihood of borrowing from the Fed is insignificant. However, at Z-score level of about 100, the mean Z-score for users in Q4 2007, the relation becomes negative.

Table 5
Hazard model: discount window loan initiation.
This table reports hazard model estimates modeling the probability of an institution accessing the discount window between 8/21/2007 and 6/30/2009. Accessing the discount window means that firm takes out a loan on a particular day. The model allows for time-varying covariates and for multiple events per institutions (Andersen and Gill (1982)). If a loan has longer maturity than one business day, only the loan initiation date is included in the analysis (i.e. 30-day loan taken out on 1/1/2008 is used in the hazard model only on 1/1/2008 and the observations for the institution for the period 1/2/2008 through 1/31/2008 are deleted). Time is relative to the beginning of availability of the discount window data, except for the Post-Lehman period for which the beginning is 9/15/2008. The sample includes institutions accessing as well as not accessing (users and non-users) the Fed facilities during the crisis. All variables are allowed to change daily. All regressions include Federal Reserve district indicators and indicators denoting the frequency of accounting data. (q) and (d) denotes the quarterly and daily measurement frequency relative to the loan initiation. Insolvency Index is a sum of the following indicator variables: Equity/TA is below median, ROA is negative, Non-Perf. Loans/TA are above median, MB is below median of the in-sample distribution, and Failed Indicator. Penalty rate over DW rate is calculated daily as the difference between the target Federal Funds rate and the primary credit discount window rate. ***, **, * denotes statistical significance at the 1%, 5%, and 10% level, respectively. p-values in parentheses. Numbers in brackets report the p-values of the test of equality of the coefficients in the two sub-periods.

Panel A: All institutions	8/21/2007–9/15/2008 (Pre-Lehman)					9/16/2008–6/30/2009 (Post-Lehman)				
	1	2	3	4	5	6	7	8	9	10
S-T debt / TA (q-1)	6.12***	5.27***	1.25	5.35***	5.66***	9.05***	6.86***	9.92***	6.95***	3.84**
	(0.00)	*(0.00)*	*(0.38)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.01)*
						[0.14]	*[0.24]*	*[0.00]*	*[0.33]*	*[0.29]*
Deposits / TA (q-1)	–0.86	–1.33**	–3.25***	–1.44***	0.71	2.10**	1.36	6.11***	1.82**	2.02*
	(0.16)	*(0.01)*	*(0.00)*	*(0.01)*	*(0.35)*	*(0.02)*	*(0.14)*	*(0.01)*	*(0.05)*	*(0.07)*
						[0.00]	*[0.00]*	*[0.00]*	*[0.00]*	*[0.10]*
	–2.83***	–3.68***	–6.20***	–3.85***	–0.50	–3.04**	–3.99***	–4.75	–3.86***	–3.17
	(0.01)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.70)*	*(0.04)*	*(0.00)*	*(0.15)*	*(0.01)*	*(0.11)*
						[0.97]	*[0.78]*	*[0.49]*	*[0.63]*	*[0.83]*
Equity / TA (q–1)	15.42***					14.06***				
	(0.00)					*(0.00)*				
						[0.81]				
ROA (q–1)	30.57**					–29.17***				
	(0.03)					*(0.00)*				
						[0.00]				
Non-Perf. Loans / TA (q–1)	14.66***					6.30***				
	(0.00)					*(0.01)*				
						[0.02]				
MB (d–1)	2.69***					–2.85*				
	(0.00)					*(0.05)*				
						[0.00]				
Failed indicator	–0.82**					–0.39				
	(0.01)					*(0.25)*				
						[0.21]				
Insolvency index (d)		–0.08*	–0.94***				0.09*	1.48**		
		(0.05)	*(0.00)*				*(0.08)*	*(0.02)*		
							[0.00]	*[0.00]*		
Insolvency Index ***X*** [S-T Debt / TA]			1.84***					-1.12		
			(0.00)					*(0.24)*		
								[0.00]		
Insolvency index ***X*** [Deposits / TA]			0.96**					–1.80**		
			(0.03)					*(0.01)*		
								[0.00]		
Insolvency index ***X*** [FHLB / TA]			1.04*					0.48		
			(0.09)					*(0.68)*		
								[0.67]		
Z score				0.001	0.046***				–0.003**	0.002
				(0.20)	*(0.00)*				*(0.02)*	*(0.91)*
									[0.04]	*[0.03]*
Z score ***X*** [S-T debt / TA]					–0.015					0.062***
					(0.19)					*(0.01)*
										[0.01]
Z score ***X*** [Deposits / TA]					–0.059***					–0.014
					(0.00)					*(0.54)*
										[0.06]
Z score ***X*** [FHLB / TA]					–0.068***					–0.020
					(0.00)					*(0.46)*
										[0.36]
Penalty rate over FF rate (d)	6.57	7.30	7.12	7.69	7.51	–2.42	–2.58	–2.86	–2.72	–2.69
	(0.56)	*(0.54)*	*(0.53)*	*(0.53)*	*(0.52)*	*(0.28)*	*(0.19)*	*(0.17)*	*(0.16)*	*(0.16)*
Made acquisition in prior 30 days	0.78**	0.75**	0.71**	0.74**	0.69**	–12.63	–12.09	–12.29	–12.07	–11.95
	(0.02)	*(0.02)*	*(0.03)*	*(0.02)*	*(0.04)*	*(0.98)*	*(0.97)*	*(0.98)*	*(0.97)*	*(0.97)*
Foreign institution indicator	–1.09***	–1.36***	–1.38***	–1.34***	–1.16***	–2.20***	–2.57***	–2.34***	–2.68***	–2.66***
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
Total assets (q–1) [trillions]	1.08***	0.65***	0.69***	0.63***	0.63***	0.67**	0.57*	0.36	0.65**	0.66**
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.05)*	*(0.05)*	*(0.22)*	*(0.03)*	*(0.02)*
TARP balance indicator (q)						–0.41**	–0.44***	–0.42***	–0.50***	–0.51***
						(0.01)	*(0.00)*	*(0.01)*	*(0.00)*	*(0.00)*
Forced TARP indicator						–0.57	–0.46	0.31	–0.58	–0.62
						(0.47)	*(0.52)*	*(0.68)*	*(0.41)*	*(0.38)*
S&P 500 return (d)	–3.61	–2.92	–2.85	–2.54	–4.25	0.42	1.25	1.96	1.02	1.11
	(0.85)	*(0.88)*	*(0.88)*	*(0.89)*	*(0.83)*	*(0.95)*	*(0.83)*	*(0.75)*	*(0.86)*	*(0.85)*
Pr(Likelihood ratio)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations total	74,344	74,344	74,344	74,344	74,344	51,431	51,431	51,431	51,431	51,431
Observations with event	399	399	399	399	399	220	220	220	220	220

(*continued on next page*)

Table 5 (*continued*)

Panel A: US institutions only	8/21/2007–9/15/2008 (Pre-Lehman)					9/16/2008–6/30/2009 (Post-Lehman)				
	1	2	3	4	5	6	7	8	9	10
S-T debt / TA (q–1)	6.57***	5.19***	0.74	5.23***	5.07***	9.39***	6.70***	8.20***	6.80***	4.29***
	(0.00)	*(0.00)*	*(0.64)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.01)*
						[0.20]	*[0.25]*	*[0.01]*	*[0.24]*	*[0.65]*
Deposits / TA (q–1)	–2.76***	–2.52***	–4.79***	–2.57***	–0.76	1.71*	0.65	3.97*	1.10	1.88
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.26)*	*(0.07)*	*(0.46)*	*(0.09)*	*(0.22)*	*(0.10)*
						[0.00]	*[0.00]*	*[0.00]*	*[0.00]*	*[0.03]*
FHLB advances / TA	–3.85***	–4.35***	–7.27***	–4.44***	–1.81	–3.08**	–4.29***	–6.62**	–4.15***	–3.02
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.18)*	*(0.04)*	*(0.00)*	*(0.05)*	*(0.00)*	*(0.12)*
						[0.97]	*[0.73]*	*[0.76]*	*[0.55]*	*[0.82]*
Equity / TA (q–1)	19.46***					15.49***				
	(0.00)					*(0.00)*				
						[0.85]				
ROA (q–1)	33.00**					–29.60***				
	(0.02)					*(0.00)*				
						[0.00]				
Non-Perf. loans / TA (q-1)	16.36***					6.61***				
	(0.00)					*(0.00)*				
						[0.02]				
MB (d–1)	2.30***					–3.17**				
	(0.01)					*(0.03)*				
						[0.01]				
Failed indicator	–1.04***					–0.61				
	(0.01)					*(0.12)*				
						[0.66]				
Insolvency index (d)		–0.06	–1.06***				0.09*	1.04		
		(0.14)	*(0.01)*				*(0.09)*	*(0.12)*		
							[0.01]	*[0.00]*		
Insolvency index ***X*** [S-T debt / TA]			1.96***					–0.54		
			(0.00)					*(0.58)*		
								[0.02]		
Insolvency index ***X*** [Deposits / TA]			1.12**					–1.30		
			(0.03)					*(0.10)*		
								[0.00]		
Insolvency index ***X*** [FHLB / TA]			1.25*					1.06		
			(0.07)					*(0.37)*		
								[0.96]		
Z score				0.001	0.047***				–0.002**	0.020
				(0.40)	*(0.00)*				*(0.03)*	*(0.30)*
									[0.06]	*[0.05]*
Z score ***X*** [S-T debt / TA]					–0.014					0.044*
					(0.22)					*(0.06)*
										[0.01]
Z score ***X*** [Deposits / TA]					–0.061***					–0.034
					(0.00)					*(0.15)*
										[0.08]
Z score ***X*** [FHLB / TA]					–0.065***					–0.036
					(0.00)					*(0.19)*
										[0.50]
Penalty rate over FF rate (d)	2.33	3.42	3.17	3.75	3.20	–2.56	–2.66	–2.99	–2.79	–2.80
	(0.89)	*(0.84)*	*(0.85)*	*(0.83)*	*(0.85)*	*(0.25)*	*(0.18)*	*(0.14)*	*(0.15)*	*(0.14)*
Made acquisition in prior 30 days	0.91***	0.77**	0.75**	0.76**	0.73**	–12.39	–11.93	–12.34	–11.95	–11.90
	(0.01)	*(0.02)*	*(0.02)*	*(0.02)*	*(0.03)*	*(0.98)*	*(0.98)*	*(0.98)*	*(0.98)*	*(0.97)*
Total assets (q–1) [trillions]	0.78***	0.53***	0.54***	0.54***	0.40*	–1.33**	–1.29*	–1.31*	–1.21*	–1.17
	(0.00)	*(0.01)*	*(0.01)*	*(0.00)*	*(0.05)*	*(0.05)*	*(0.06)*	*(0.06)*	*(0.08)*	*(0.10)*
TARP balance indicator (q)						–0.44***	–0.45***	–0.44***	–0.51***	–0.54***
						(0.01)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
Forced TARP indicator						2.08**	1.87**	2.09**	1.77**	1.61*
						(0.01)	*(0.03)*	*(0.02)*	*(0.04)*	*(0.08)*
S&P 500 return (d)	3.06	5.24	5.32	5.31	4.47	–0.48	0.67	1.35	0.44	0.48
	(0.88)	*(0.79)*	*(0.79)*	*(0.79)*	*(0.83)*	*(0.94)*	*(0.91)*	*(0.83)*	*(0.94)*	*(0.94)*
Pr(Likelihood ratio)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations total	68,655	68,655	68,655	68,655	68,655	47,048	47,048	47,048	47,048	47,048
Observations with event	363	363	363	363	363	211	211	211	211	211

The results for the pre-Lehman period for US institutions, reported in Panel B, are generally in line with the results in Panel A. Overall, we interpret the results for the pre-Lehman period as being weakly consistent with the liquidity framework.

The test of the liquidity provision loan initiation hypothesis (H3A) focuses on the changes in the coefficients as the crisis deepens. In Table 5 Panels A and B, we examine H3A in models (6) through (10) with data in the post-Lehman period and test whether the coefficients are significantly different from zero. We also consider whether the coefficients change relative to the pre-Lehman period. We would fail to reject H3A if the coefficients on ST debt and, in some models, the net effects of ST debt and its interaction variables, are significantly positive and significantly larger than in the pre-Lehman period. The p-value in parentheses in these specifications relates to the test of whether the coefficient is different from zero, while the p-value in the brackets below reports the outcome of the test of the difference in the coefficients between the two periods.

The coefficients on ST debt are significantly positive in all models, but their increases during the worst part of the crisis period (when debt markets froze) are not significant. While most of the coefficients on ST debt are larger in models (6)-(10), with one exception (model (8)) the increase is not statistically significant. The result in model (8) is consistent with the liquidity provision loan initiation hypothesis (H3A), while the results in all the remaining models are not. The coefficients on deposits are generally significant in the later period. However, they change to the incorrect sign. With respect to the interaction terms, the only significant coefficients are those of deposits in model (8) and ST debt in model (10). Again, the results for US banks in Panel B are generally consistent with these findings although their statistical significance is even weaker. Hence, there is at best weak evidence in support of H3A for DW loans.

In the early part of the crisis, banks that use FHLB advances are significantly less likely to borrow at the discount window. This finding suggests that the LOLR role is hampered by the high cost of penalty interest rates. The coefficients on FLHB advances are also significantly negative in the post-Lehman period, but the magnitude of the effect is never significantly different from that in the pre-Lehman period. This result suggests that the DW program was not an effective LOLR tool even in the depths of the subprime crisis.

After Lehman, many of the indicators of bank health become important for explaining DW borrowing. In model (6) three of the five solvency measures are significant and indicate that DW users are more likely to be weaker firms. Furthermore, the tests of changes for these three variables, ROA, non-performing loans, and market-to-book ratio, indicate that the coefficients are significantly different from their counterparts in model (1). If we instead measure bank health with the insolvency index, the positive and significant coefficients in models (7) and (8) lend further support to the bailout loan initiation hypothesis (H3B). The Z-score paints a similar picture in model (9).

The results for US banks after Lehman in Panel B are generally consistent with the results for the whole sample and further support the bailout loan initiation hypothesis (H3B) as well. The negative coefficients on ROA and market-to-book, as well as the positive coefficient on non-performing loans are all significant and have signs consistent with H3B. The tests on changes indicate that all three coefficients are significantly different from their counterparts in model (1). If we measure bank health with the insolvency index, the positive and significant coefficient (Panel B, model (7)) lends further support to the bailout loan initiation hypothesis (H3B) and implies that weaker banks are more likely to access the DW in the post-Lehman period. The coefficients on the insolvency index and Z-score change significantly when compared to their pre-Lehman counterparts. Hence, the results for US banks further corroborate the bailout loan initiation hypothesis (H3B).

We also consider whether borrowing is affected by the penalty rate in Table 5 by including a variable that measures the difference between the interest rates on DW and repo loans. While this is not an apples-to-apples comparison once the Fed accepts a wider range of collateral in September 2008, the change in sign of the penalty variable suggests the higher cost of Fed loans played a role in banks' borrowing decisions. However, the coefficient is never significantly different from zero. After Lehman's bankruptcy, foreign banks decrease their borrowing, while acquirers are less likely to borrow than they were prior to Lehman's bankruptcy. Consistent with the size of the banks reported in Table 2, Table 5 Panel B shows that smaller U.S. banks are significantly *more* likely to access the DW in the post-Lehman period, even though they are not the expected victims of stress in short-term debt markets. Finally, the evidence on DW usage by TARP banks is mixed, indicating that while US banks that reported TARP balances in a particular quarter were less likely to borrow from the Fed, the subset of institutions forced to use TARP were significantly more likely to borrow from the DW (Panel B).[23]

Overall, based on the multivariate analysis of DW loan initiations in Table 5, the Fed may have followed the Bagehot rule when markets first showed signs of weakness; however, the estimates from the post-Lehman period suggest that DW loans often propped up weak banks.[24]

Table 6, Panels A and B show the same specifications of the hazard function for TAF borrowing, except for the pre-Lehman time period since TAF started in late 2007. The sample used in these analyses includes only the auction dates. Consistent with the DW results, during the pre-Lehman period reliance on ST debt and deposits are significant factors behind the decision to borrow from the Fed. Similarly, once the insolvency variable interactions are included in model (3), ST debt is no longer significant and neither is the deposits variable. In contrast to the DW estimations, the TAF regression estimates indicate that insolvent institutions were more likely to borrow from the Fed in the pre-Lehman period. The insolvency index interactions with ST debt and deposits are insignificant. The Z-score variable suggests the opposite result of the insolvency variable, as higher Z-score banks are less likely to borrow from TAF in the earlier period. Z-score interaction terms are all significant and provide some support for the liquidity provision framework.

For the post-Lehman period, the coefficients on ST debt are similar to those of their pre-Lehman counterparts. The coefficients on deposits in the post-Lehman period are largely significant, although they are more often significant and negative in the sample of US banks. Overall, we interpret these results to provide weak support for H3A.

As with the DW, banks that rely more on FHLB advances are less likely to borrow from the Fed via the TAF. In contrast to the results for DW in Table 5, FHLB advances have a much larger impact after Lehman on the likelihood of obtaining a TAF loan, with the coefficients being at least double in magnitude compared to the earlier period. Ashcraft et al. (2010) argue that the relative cheapness of FHLB advances increased sharply after Lehman, consistent with our hypothesis that weaker banks bid more aggressively in the auctions as the crisis deepened. Thus, the use of FHLB advances by TAF borrowers contradicts H3A and provides some support for H3B.

Table 6 shows much more evidence in favor of the bailout framework during the early crisis period than is the case for the DW analysis in Table 5. In Table 6, equity, ROA, market to book, the failed indicator, and the insolvency index all suggest that weaker banks were more likely to borrow regardless of the time period. The insolvency index enters with a significant positive coefficient in models (2), (3), and (8) in Panel A and in all models in Panel B. In contrast, the Z-score indicates that healthier banks borrowed via TAF early on. Most of the solvency measures have smaller absolute values of the coefficients and some are insignificant in the post-

[23] These institutions include Bank of America, Bank of New York, Citibank, Goldman Sachs, J.P. Morgan, Merrill Lynch, Morgan Stanley, State Street, and Wells Fargo. U.S. Treasury Secretary Paulson's talking points for a meeting with CEOs of these banks contained the following language "...We don't believe it is tenable to opt out because doing so would leave you vulnerable and exposed. If a capital infusion is not appealing, you should be aware your regulator will require it in any circumstance." For details see, http://www.businessinsider.com/uncovered-tarp-docs-reveal-how-paulson-forced-banks-to-take-the-cash-2009-5.

[24] Table 1 indicates that the distribution of loan sizes is skewed. Thus, the multivariate analyses reported in Tables 5–8 use hazard models of whether borrowing occurred instead of regressions using the amount borrowed. In an untabulated robustness check we consider loan size by estimating a Tobit regression where the dependent variables in Tables 5–8 arereplaced by the total amount of debt borrowed on a particular day scaled by assets. Our conclusions are not affected when we use Tobit regressions analyzing amount borrowed.

Table 6
Hazard model: TAF loan initiations.
This table reports hazard model estimates modeling the probability of an institution accessing the TAF between 12/12/2007 and 6/30/2009. The model allows for time-varying covariates and for multiple events per institutions (Andersen and Gill (1982)). Accessing the TAF means that a firm takes out a loan on a particular auction day. Only the loan initiation date is included in the analysis (i.e. 30-day loan taken out on 1/1/2008 is used in the hazard model only on 1/1/2008 and the observations for the institution for the period 1/2/2008 through 1/31/2008 are deleted). Time is relative to the beginning of availability of the data, except for the Post-Lehman period for which the beginning is 9/15/2008. The sample includes institutions accessing as well as not accessing (users and non-users) the Fed facilities during the crisis. All variables are allowed to change daily. All regressions include Federal Reserve district indicators and indicators denoting the frequency of accounting data. (q) and (d) denotes the quarterly and daily measurement frequency relative to the loan initiation. ***, **, * denotes statistical significance at the 1%, 5%, and 10% level, respectively. p-values in parentheses. Numbers in brackets report the p-values of the test of equality of the coefficients in the two sub-periods.

Panel A: All institutions	12/12/2007–9/15/2008 (Pre-Lehman)					9/16/2008–6/30/2009 (Post-Lehman)				
	1	2	3	4	5	6	7	8	9	10
S-T debt / TA (q–1)	4.14***	5.26***	2.38	4.51***	1.12	6.38***	6.81***	4.89***	6.68***	5.23***
	(0.00)	*(0.00)*	*(0.27)*	*(0.00)*	*(0.45)*	*(0.00)*	*(0.00)*	*(0.01)*	*(0.00)*	*(0.00)*
						[0.89]	*[0.39]*	*[0.81]*	*[0.56]*	*[0.09]*
Deposits / TA (q–1)	–2.63***	–1.92***	–0.74	–2.79***	–2.19***	–0.62	–0.51	1.82*	–0.64	–0.16
	(0.00)	*(0.00)*	*(0.54)*	*(0.00)*	*(0.00)*	*(0.36)*	*(0.41)*	*(0.05)*	*(0.30)*	*(0.81)*
						[0.70]	*[0.25]*	*[0.30]*	*[0.30]*	*[0.51]*
FHLB advances / TA (q–1)	–10.17***	–8.23***	–12.93***	–8.27***	–5.59**	–20.30***	–19.02***	–35.70***	–18.96***	–18.52***
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.03)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
						[0.00]	*[0.00]*	*[0.00]*	*[0.00]*	*[0.00]*
Equity / TA (q–1)	–7.43**					–4.52*				
	(0.01)					*(0.10)*				
						[0.85]				
ROA (q–1)	–21.34**					–15.80**				
	(0.01)					*(0.01)*				
						[0.85]				
Non-Perf. loans / TA (q–1)	–17.19**					–15.22***				
	(0.01)					*(0.01)*				
						[0.78]				
MB (d–1)	–1.97					–0.44				
	(0.23)					*(0.80)*				
						[0.56]				
Failed indicator	2.03***					1.14***				
	(0.00)					*(0.00)*				
						[0.37]				
Insolvency index (d)		0.41***	0.66**				0.05	0.67**		
		(0.00)	*(0.05)*				*(0.42)*	*(0.02)*		
							[0.00]	*[0.36]*		
Insolvency index ***X*** [S-T debt / TA]			1.01					1.12		
			(0.20)					*(0.14)*		
								[0.83]		
Insolvency index ***X*** [Deposits / TA]			–0.64					–1.22***		
			(0.15)					*(0.00)*		
								[0.04]		
Insolvency index ***X*** [FHLB / TA]			1.45					7.18***		
			(0.14)					*(0.00)*		
								[0.00]		
Z score				0.004***	0.024***				0.002	0.023**
				(0.00)	*(0.01)*				*(0.20)*	*(0.02)*
									[0.15]	*[0.92]*
Z score ***X*** [S-T debt / TA]					0.053***					0.023
					(0.00)					*(0.28)*
										[0.25]
Z score ***X*** [Deposits / TA]					–0.035***					–0.034**
					(0.00)					*(0.01)*
										[0.93]
Z score ***X*** [FHLB / TA]					–0.045*					–0.019
					(0.09)					*(0.70)*
										[0.95]
Made acquisition in prior 30 days	0.26	0.09	0.11	0.25	0.43	–0.21	–0.19	–0.29	–0.17	–0.21
	(0.58)	*(0.86)*	*(0.82)*	*(0.60)*	*(0.36)*	*(0.69)*	*(0.72)*	*(0.59)*	*(0.75)*	*(0.70)*
Foreign institution indicator	0.69**	0.78***	0.76***	0.58**	0.51*	0.46	0.60**	0.69***	0.60**	0.38
	(0.04)	*(0.01)*	*(0.01)*	*(0.05)*	*(0.09)*	*(0.17)*	*(0.02)*	*(0.01)*	*(0.02)*	*(0.17)*
Total assets (q–1) [trillions]	0.19	0.43***	0.40***	0.51***	0.47***	0.41***	0.67***	0.63***	0.69***	0.72***
	(0.13)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
TARP balance indicator (q)	1.40***	1.27***	1.26***	1.22***	1.06***	0.55***	0.54***	0.58***	0.57***	0.46***
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.01)*
Forced TARP indicator	0.45	0.34	0.52	–0.12	–0.57	0.78**	0.59**	0.80***	0.52*	0.28
	(0.18)	*(0.29)*	*(0.12)*	*(0.72)*	*(0.10)*	*(0.01)*	*(0.04)*	*(0.01)*	*(0.07)*	*(0.35)*
S&P 500 return (d)	–2.24	2.96	1.04	3.76	11.29	1.15	–0.18	1.72	–1.07	–4.89
	(0.94)	*(0.92)*	*(0.97)*	*(0.89)*	*(0.70)*	*(0.87)*	*(0.98)*	*(0.80)*	*(0.87)*	*(0.43)*
Pr(Likelihood ratio)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations total	5,924	5,924	5,924	5,924	5,924	6,070	6,070	6,070	6,070	6,070
Observations with event	244	244	244	244	244	302	302	302	302	302

(*continued on next page*)

Table 6 (*continued*)

Panel B: US institutions only	12/12/2007–9/15/2008 (Pre-Lehman)					9/16/2008–6/30/2009 (Post-Lehman)				
	1	2	3	4	5	6	7	8	9	10
S-T Debt / TA (q–1)	5.44***	5.00***	3.25	4.13***	1.59	7.92***	6.96***	9.60***	7.06***	7.34***
	(0.00)	*(0.00)*	*(0.27)*	*(0.00)*	*(0.41)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
						[0.68]	*[0.64]*	*[0.54]*	*[0.30]*	*[0.03]*
Deposits / TA (q–1)	–3.18***	–3.71***	–0.34	–4.22***	–2.51***	–1.71**	–2.48***	1.88	–2.52***	–0.52
	(0.00)	*(0.00)*	*(0.84)*	*(0.00)*	*(0.00)*	*(0.05)*	*(0.00)*	*(0.16)*	*(0.00)*	*(0.50)*
						[1.00]	*[0.90]*	*[0.61]*	*[0.46]*	*[0.39]*
FHLB advances / TA (q–1)	–10.51***	–8.81***	–10.22***	–8.75***	–7.37***	–21.02***	–18.87***	–27.98***	–18.49***	–15.62***
	(0.00)	*(0.00)*	*(0.01)*	*(0.00)*	*(0.01)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
						[0.00]	*[0.00]*	*[0.00]*	*[0.00]*	*[0.15]*
Equity / TA (q–1)	–2.64					–0.78				
	(0.45)					*(0.82)*				
						[0.38]				
ROA (q–1)	–15.09					–9.54				
	(0.28)					*(0.22)*				
						[0.91]				
Non-Perf. loans / TA (q–1)	–11.45					–15.32**				
	(0.10)					*(0.02)*				
						[0.92]				
MB (d–1)	–7.00***					–6.32***				
	(0.00)					*(0.01)*				
						[0.48]				
Failed indicator	2.27***					2.35***				
	(0.00)					*(0.00)*				
						[0.35]				
Insolvency index (d)		0.58***	1.58***				0.21***	2.03***		
		(0.00)	*(0.00)*				*(0.00)*	*(0.00)*		
							[0.00]	*[0.78]*		
Insolvency index ***X*** [S-T debt / TA]			0.26					–1.85*		
			(0.80)					*(0.08)*		
								[0.54]		
Insolvency index ***X*** [Deposits / TA]			–1.64**					–2.50***		
			(0.01)					*(0.00)*		
								[0.41]		
Insolvency index ***X*** [FHLB / TA]			0.40					3.29		
			(0.72)					*(0.14)*		
								[0.06]		
Z score				0.004***	0.064***				0.002	0.093***
				(0.00)	*(0.00)*				*(0.12)*	*(0.00)*
									[0.49]	*[0.03]*
Z score ***X*** [S-T debt / TA]					0.007					–0.038
					(0.70)					*(0.12)*
										[0.04]
Z score ***X*** [Deposits / TA]					–0.088***					–0.120***
					(0.00)					*(0.00)*
										[0.07]
Z score ***X*** [FHLB / TA]					–0.057**					–0.108*
					(0.03)					*(0.06)*
										[0.17]
Made acquisition in prior 30 days	0.18	0.02	0.04	0.18	0.25	–0.33	–0.26	–0.40	–0.20	–0.34
	(0.71)	*(0.97)*	*(0.93)*	*(0.70)*	*(0.60)*	*(0.54)*	*(0.64)*	*(0.47)*	*(0.71)*	*(0.53)*
Foreign institution indicator										
Total assets (q–1) [trillions]	0.26	0.71	0.88*	1.03**	0.96**	0.17	0.32	0.30	0.38	0.54
	(0.58)	*(0.14)*	*(0.06)*	*(0.04)*	*(0.04)*	*(0.60)*	*(0.32)*	*(0.35)*	*(0.23)*	*(0.11)*
TARP balance indicator (q)	1.67***	1.40***	1.34***	1.32***	1.10***	0.65***	0.59***	0.56***	0.67***	0.38**
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.04)*
Forced TARP indicator	0.25	–0.36	–0.20	–1.17	–1.88***	0.78	0.62	0.86	0.43	–0.23
	(0.71)	*(0.61)*	*(0.76)*	*(0.12)*	*(0.00)*	*(0.18)*	*(0.29)*	*(0.13)*	*(0.45)*	*(0.70)*
S&P 500 return (d)	–13.92	–0.77	–1.43	–6.77	13.11	0.70	4.66	9.83	6.97	12.11
	(0.76)	*(0.99)*	*(0.97)*	*(0.86)*	*(0.72)*	*(0.95)*	*(0.66)*	*(0.38)*	*(0.52)*	*(0.22)*
Pr(Likelihood ratio)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations total	5,387	5,387	5,387	5,387	5,387	5,515	5,515	5,515	5,515	5,515
Observations with event	170	170	170	170	170	191	191	191	191	191

Lehman period. In that sense, the results are in conflict with the DW estimates, which showed that weaker banks were more likely to use the window after Lehman. The contrasting results may owe to the fact that DW loans are made at a penalty rate whereas the TAF minimum is set by auction. Although weak banks have an incentive to bid more aggressively in TAF auctions than strong banks, it is still the case that the cost of replacing frozen debt market funds is cheaper if one uses the TAF instead of DW loans. Foreign banks are more likely to borrow from the TAF in both periods, as are larger banks (which likely have more expertise with bidding in auctions).

Overall, the evidence on TAF usage shows some evidence favoring the liquidity provision hypothesis for US banks (Table 6, Panel B). The results also show that weak banks show similar propensity to access TAF in both pre- and post-Lehman periods. However, the results do not support the bailout loan initiation hypothesis in that weak banks were no more likely to access TAF during the period of market turmoil.

We further investigate whether TAF loans helped thaw frozen capital markets by analyzing participation levels in the auctions. Fig. 4 indicates that TAF auctions were not always fully subscribed during the sample period – the gray background indicates that the amount borrowed by bidders is less than the amount available. In untabulated results, we regress the subscription ratio (calculated as the total of dollar bids submitted divided by the size of the auction) less one on measures of market conditions as well as features of the loans being auctioned. The dependent variable is larger (smaller) than zero whenever there is oversubscription (undersubscription) and banks desire more (fewer) funds than available via TAF loans. Under H3A, we expect TAF auctions post-Lehman to be significantly oversubscribed (i.e., the coefficient on the time period indicator to be significantly positive), but we find that of the 44 TAF auctions in our sample period only those in the pre-Lehman period are significantly oversubscribed. The post-Lehman and pre-TARP period (9/15–10/28/2008) is characterized by insignificant oversubscription and the post-TARP period is marked by significant undersubscription. Loan-specific maturity characteristics and market return on the day before the auction are both insignificant predictors of the level of TAF participation.

While the results on the lack of oversubscription during the post-Lehman period contradict H3A, it is possible that the size of TAF auctions was increased by the Fed in response to market disruptions so that they provided sufficient liquidity. The total TAF amount was raised from $600 billion in December 2008 to $900 billion for a short time. We note, however, that the auction size is always below 20% of total short-term debt, which, as Fig. 2 shows, is around $5 trillion in aggregate. Moreover, some of the TAF borrowing was done by smaller banks that are not in our sample (Fig. 4), indicating that TAF provided well under 10% of the short-term funding required by our sample firms even in Fall 2008. We conclude that while TAF attracted more participation as short-term debt markets seized up, it did not succeed in attracting a higher fraction of healthier banks than DW, despite the fact that its loans did not carry a penalty. We conjecture that since the auctions are infrequent and do not guarantee timely loans in a pinch, healthy banks are forced to obtain alternative funds in the event that more aggressive bidders shut them out of the TAF auction.

We next consider borrowing from the PDCF with a multiple event hazard function. H3A predicts that the ST debt variable will be more important in these models and H2A predicts that the impact will be greatest after Lehman fails, since primary dealers tend to rely heavily on ST debt to fund their balance sheets (Table 2, Panel A). Counter to the liquidity framework, Table 7 reveals that PDCF usage is generally *negatively* related to a dealer's ST debt during the pre-Lehman period or not related at all. While the ST debt coefficients increase significantly for the post-Lehman period, the coefficients themselves are insignificant in models (6) through (8). In models (9) and (10), we note that after controlling for the Z-score, the negative coefficient on ST debt becomes significant, and the declines in the coefficients from their pre-Lehman counterparts are significant. Hence, there is some evidence that even during the post-Lehman period, PDCF usage is *negatively* related to a dealer's ST debt. Prior to Lehman, deposits affect the likelihood of borrowing from PDCF negatively in models (1) and (3) and positively in model (5). After Lehman, deposits have a significant negative effect in models (6) through (8) and a significant positive effect in model (10). The decline in the coefficient is significant in model (8) only. These results might reflect a switch from ST debt to deposits by some primary dealers, especially as the largest primary dealers converted to bank holding companies, which likely helped them attract more deposits. The coefficients on the interaction terms are generally consistent with their Table 5 counterparts. Overall, PDCF use provides very little evidence in support of H3A.

Turning to the measures of solvency, the PDCF is more likely to be used when a dealer is closer to default in both periods, but the insolvency measures are stronger in the pre-Lehman period. During the post-Lehman period, the usage of PDCF is still related to solvency characteristics, however, the relationships are sometimes weaker. The measures that indicate a greater role for bank health after Lehman are market-to-book, insolvency index, and Z-score. While the coefficient on the failed indicator during the post-Lehman period remains positive and statistically significant, its magnitude declines relative to the pre-Lehman period. Overall, the results show that institutions closer to default continued to be more likely to use PDCF loans, although, the likelihood of accessing PDCF by weak firms does not increase during times of market turmoil.

With respect to the control variables, consistent with the DW and contrary to the TAF facilities, the PDCF is less likely to be used by foreign firms. The coefficient on the indicator for primary dealers that converted to bank holding companies is significantly positive in all post-Lehman models, indicating a preference for PDCF even when other Fed facilities are available. Finally, institutions using TARP are also more likely to access PDCF in models (6) through (8).[25]

Overall, the findings in Table 7 for PDCF show little support for the liquidity provision loan initiation hypothesis. The results indicate that during the whole sample period, weak institutions were more likely to access PDCF. However, this relationship did not increase during the post-Lehman period, suggesting that the facility drew in somewhat healthier banks as the penalty rate declined.

Table 8 shows the same specifications of the hazard function for TSLF borrowing, except for the time periods (reflecting the later start of the TSLF). Additionally, Table 8 analysis includes only auction dates. Compared to the PDCF, TSLF borrowing is more closely related to a dealer's funding model. Both ST debt and deposits are significant in the pre-Lehman period in at least one model and have signs that support the liquidity framework. While the coefficients tend to be larger in absolute value in the post-Lehman period than in the pre-Lehman period, the increases are not statistically significant, which contradicts H3A. With the exception of deposits, the interaction terms are insignificant during the pre-Lehman period providing some support for H3A. During the post-Lehman period, the effect of insolvency dominates the effect implied by the coefficients on the interaction terms. Furthermore, the interaction terms involving Z-score are all insignificant during the post-Lehman period.

Contrary to the results for the PDCF, with the exception of the failed bank indicator, measures of solvency are either insignificant or suggest that weaker firms refrained from using TSLF (Z-score in model (5)) in the pre-Lehman period. In the post-Lehman period, the coefficients on the failed bank indicator, the insolvency index, and Z-score suggest that weaker primary dealers were significantly more likely to access the TSLF. On balance, the results provide support for the bailout hypothesis H3B.

With respect to the control variables, we find that larger firms are more likely to use TSLF, again suggesting that they have more expertise with auctions. Models (6)–(10) capture the possibility of arbitrage, since they include an indicator variable for the period in late 2008 when the rate on TSLF loans is below the interest rate on excess reserves, but the variable is not significant. Perhaps not surprisingly, firms that converted to a bank charter are less likely to participate in TSLF auctions. TARP users are less likely to access TSLF than TARP non-users. Overall, the results presented in Table 7 provide some support to the bailout framework. The re-

[25] We note that the forced TARP indicator cannot be included in the model because it is collinear with the indicator for banks with TARP balances (correlation of 0.94).

Table 7
Hazard model: PDCF loan initiations.
This table reports hazard model estimates modeling the probability of an institution accessing the PDCF between 3/17/2007 and 6/30/2009. The model allows for time-varying covariates and for multiple events per institutions (Andersen and Gill (1982)). Accessing the PDCF means that a firm takes out a loan on a particular day. If a loan has longer maturity than one business day, only the loan initiation date is included in the analysis (i.e. 30-day loan taken out on 1/1/2008 is used in the hazard model only on 1/1/2008 and the observations for the institution for the period 1/2/2008 through 1/31/2008 are deleted). Time is relative to the beginning of availability of the data, except for the Post-Lehman period for which the beginning is 9/15/2008. The sample includes only primary dealers. All regressions include indicators denoting the frequency of accounting data. (q) and (d) denotes the quarterly and daily measurement frequency relative to the loan initiation. ***, **, * denotes statistical significance at the 1%, 5%, and 10% level, respectively. p-values in parentheses. Numbers in brackets report the p-values of the test of equality of the coefficients in the two sub-periods.

	3/17/2008–9/15/2008 (Pre–Lehman)					9/16/2008–6/30/2009 (Post-Lehman)				
	1	2	3	4	5	6	7	8	9	10
S-T Debt / TA (q–1)	–6.72***	–2.75***	–17.77***	–1.31	7.79***	–0.75	–1.51	2.38	–2.61*	–5.47***
	(0.00)	*(0.00)*	*(0.00)*	*(0.19)*	*(0.00)*	*(0.71)*	*(0.34)*	*(0.24)*	*(0.10)*	*(0.00)*
						[0.00]	*[0.00]*	*[0.00]*	*[0.00]*	*[0.00]*
Deposits / TA (q–1)	–10.82***	–0.75	–23.29***	–0.87	17.15***	–6.34***	–3.37***	–8.89***	0.38	3.46***
	(0.00)	*(0.30)*	*(0.00)*	*(0.20)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.64)*	*(0.01)*
						[0.28]	*[0.10]*	*[0.02]*	*[0.00]*	*[0.00]*
Equity / TA (q–1)	–42.02***					14.63**				
	(0.00)					*(0.01)*				
						[0.01]				
ROA (q–1)	152.67*					–32.26				
	(0.07)					*(0.34)*				
						[0.06]				
MB (d–1)	–26.90***					–46.90***				
	(0.00)					*(0.00)*				
						[0.00]				
Failed indicator	2.61***					1.12***				
	(0.00)					*(0.00)*				
						[0.02]				
Insolvency index (d)		0.95***	–1.73***				0.69***	1.33***		
		(0.00)	*(0.00)*				*(0.00)*	*(0.00)*		
							[0.00]	*[0.03]*		
Insolvency index ***X*** [S-T Debt/TA]			5.70***					–2.64***		
			(0.00)					*(0.01)*		
								[0.00]		
Insolvency index ***X*** [Deposits/TA]			10.30***					0.72		
			(0.00)					*(0.14)*		
								[0.00]		
Z score				0.00	0.16***				–0.04***	–0.16***
				(0.35)	*(0.00)*				*(0.00)*	*(0.00)*
									[0.00]	*[0.00]*
Z score ***X*** [S-T debt / TA]					–0.39***					0.34***
					(0.00)					*(0.00)*
										[0.00]
Z score ***X*** [Deposits / TA]					–0.60***					–0.01
					(0.00)					*(0.81)*
										[0.00]
Foreign institution indicator	–1.93***	–1.32***	–0.83***	0.29	0.33	–2.34***	–3.51***	–3.54***	–3.10***	–3.02***
	(0.00)	*(0.00)*	*(0.01)*	*(0.28)*	*(0.24)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*
Total assets (q–1) [trillions]	0.96***	–0.16	–1.26***	–0.52***	–0.85***	0.29	0.12	0.10	–0.12	0.08
	(0.00)	*(0.26)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.27)*	*(0.61)*	*(0.70)*	*(0.60)*	*(0.76)*
TARP balance indicator (q)						1.57***	1.24***	3.55***	–0.17	–0.42
						(0.00)	*(0.00)*	*(0.00)*	*(0.62)*	*(0.20)*
Conv. to bank chrt. indicator (d)						0.58***	0.39***	0.33**	0.35**	0.39***
						(0.00)	*(0.01)*	*(0.02)*	*(0.02)*	*(0.01)*
S&P 500 return (d)	–445.29	–442.67	–418.99	–468.79	–463.92	47.36	62.75*	53.37	55.40	55.39
	(0.99)	*(0.98)*	*(0.98)*	*(0.98)*	*(0.98)*	*(0.20)*	*(0.08)*	*(0.14)*	*(0.11)*	*(0.12)*
Pr(Likelihood ratio)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations total	1,673	1,673	1,673	1,746	1,746	2,194	2,194	2,194	2,375	2,375
Observations with event	152	152	152	169	169	540	540	540	540	540

spect to the liquidity provision hypothesis, the results are mixed at best and potentially can be interpreted as contrary to the liquidity provision hypothesis H3A.

The PDCF and TSLF hazard function estimates provide mixed evidence on the role of the liquidity provision framework for primary dealers. Thus, we further investigate the level of participation in the TSLF auctions. Similar to the TAF analysis, we calculate the subscription ratio as total dollar bids submitted divided by the size of the auction and analyze whether oversubscription (a subscription ratio larger than one) occurs more often after Lehman. In untabulated results we note that in the 85 TSLF auctions in our sample period, auctions taking place before Lehman and post-TARP (after 10/28/2008) periods are undersubscribed, and significantly so in the post-TARP period. Only the auctions taking place between September 15, 2008 and October 28, 2008 are significantly oversubscribed. The TSLF arbitrage opportunity indicator enters with a significantly positive coefficient, implying that some participation in the TSLF auctions is related to the pricing of the debt. This evidence is consistent with the loan initiation hypothesis for TSLF and suggests that the penalty rate limits the appeal of the PDCF.

Overall, our analysis shows that reliance on short-term debt funding was an important factor in whether a bank or dealer bor-

Table 8
Hazard model: TSLF loan initiations.
This table reports hazard model estimates modeling the probability of an institution accessing the TSLF program between 3/27/2007 and 6/30/2009. The model allows for time-varying covariates and for multiple events per institutions (Andersen and Gill (1982)). Accessing the TSLF means that a firm's loan taken out on a particular day falls in the top 90% of all loans by users. Not accessing the TSLF includes non-users, light users, and users whose loans on particular day fall in the bottom 10% of all loans by users. Only the loan initiation date is included in the analysis (i.e. 30-day loan taken out on 1/1/2008 is used in the hazard model only on 1/1/2008). Time is relative to the beginning of availability of the data, except for the Post-Lehman period for which the beginning is 9/15/2008. The sample includes only primary dealers during the crisis. All regressions include indicators denoting the frequency of accounting data. (q) and (d) denotes the quarterly and daily measurement frequency relative to the loan initiation. ***, **, * denotes statistical significance at the 1%, 5%, and 10% level, respectively. p-values in parentheses. Numbers in brackets report the p-values of the test of equality of the coefficients in the two sub-periods.

	3/27/2008–9/15/2008 (Pre-Lehman)					9/16/2008–6/30/2009 (Post-Lehman)				
	1	2	3	4	5	6	7	8	9	10
S-T debt / TA (q–1)	1.50	1.70	3.16	2.18**	2.17	1.47	2.06	4.92**	2.44	1.23
	(0.25)	*(0.14)*	*(0.14)*	*(0.04)*	*(0.16)*	*(0.40)*	*(0.21)*	*(0.02)*	*(0.12)*	*(0.48)*
						[0.33]	*[0.92]*	*[0.77]*	*[0.35]*	*[0.28]*
Deposits / TA (q–1)	–2.07**	–1.10**	–0.79	–0.80	1.16	–2.33***	–1.63**	–0.13	–0.38	0.55
	(0.02)	*(0.02)*	*(0.43)*	*(0.16)*	*(0.22)*	*(0.00)*	*(0.01)*	*(0.91)*	*(0.59)*	*(0.60)*
						[0.70]	*[0.11]*	*[0.84]*	*[0.15]*	*[0.04]*
Equity / TA (q–1)	10.23					–3.23				
	(0.31)					*(0.70)*				
						[0.01]				
ROA (q–1)	45.33					12.36				
	(0.31)					*(0.69)*				
						[0.48]				
MB (d–1)	7.66					–11.07				
	(0.24)					*(0.11)*				
						[0.10]				
Failed indicator	0.46*					0.40**				
	(0.10)					*(0.04)*				
						[0.76]				
Insolvency index (d)		0.06	0.26				0.21***	0.71***		
		(0.43)	*(0.40)*				*(0.00)*	*(0.01)*		
							[0.02]	*[0.26]*		
Insolvency index ***X*** [S-T debt / TA]			–0.67					–1.78**		
			(0.38)					*(0.03)*		
								[0.42]		
Insolvency index ***X*** [Deposits / TA]			–0.16					–1.06*		
			(0.79)					*(0.07)*		
								[0.33]		
Z score				–0.003	0.015*				–0.009***	–0.009
				(0.29)	*(0.08)*				*(0.01)*	*(0.42)*
									[0.71]	*[0.18]*
Z score ***X*** [S-T debt / TA]					–0.028					0.046
					(0.33)					*(0.35)*
										[0.36]
Z score ***X*** [Deposits / TA]					–0.063***					–0.020
					(0.01)					*(0.44)*
										[0.18]
Foreign institution indicator	0.09	–0.43*	–0.40	–0.25	–0.25	–0.10	–0.04	–0.06	0.09	0.03
	(0.87)	*(0.10)*	*(0.13)*	*(0.29)*	*(0.29)*	*(0.82)*	*(0.87)*	*(0.81)*	*(0.73)*	*(0.91)*
Total assets (q–1) [trillions]	0.62***	0.59***	0.55***	0.60***	0.50***	0.46**	0.45**	0.48**	0.45***	0.38**
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.02)*	*(0.02)*	*(0.02)*	*(0.01)*	*(0.05)*
Arbitrage possible in TSLF						–0.34	–0.25	–0.25	–0.30	–0.28
						(0.59)	*(0.69)*	*(0.70)*	*(0.64)*	*(0.68)*
TARP balance indicator (q)						–0.06	–0.18	–0.36	–0.70**	–0.95***
						(0.88)	*(0.61)*	*(0.38)*	*(0.05)*	*(0.01)*
Conv. to bank chrt. indicator (d)						–0.72**	–0.73**	–0.71**	–0.76**	–0.81***
						(0.02)	*(0.02)*	*(0.02)*	*(0.01)*	*(0.01)*
S&P 500 return (d)	22.70**	24.47**	24.30**	24.32**	25.01**	–1.65	–1.89	–2.04	–2.15	–2.50
	(0.03)	*(0.02)*	*(0.02)*	*(0.02)*	*(0.02)*	*(0.63)*	*(0.59)*	*(0.57)*	*(0.53)*	*(0.47)*
Pr(Likelihood ratio)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations total	288	288	288	302	302	441	441	441	474	474
Observations with event	213	213	213	221	221	278	278	278	281	281

rowed from the Fed. This suggests that the programs were important substitutes for frozen capital markets. However, several results also indicate that the programs were disproportionately helpful to banks closer to insolvency: frequent instances of posting equity and corporate bond collateral, rather than the Treasury and agency MBS bonds typically seen in the repo market; measures of bank health are often significant in the multivariate analysis, suggesting that insolvency was an important reason for Fed borrowing; and numerous unusual loans, particularly to already failed foreign banks, are all inconsistent with widespread dislocations in short-term debt markets. Overall, we conclude that our evidence favors the bailout loan initiation hypothesis as much if not more than the liquidity provision hypothesis.

2.4. Tests of the loan prepayment hypotheses (H4)

Disruptions in debt markets around the time of the Lehman bankruptcy were extreme, so we expect that borrowing from Fed programs would have continued at a high level for some time.

Table 9
Hazard model: DW loan repayment.
Institutions repaying/not rolling over a discount window loan are classified as experiencing an "event/hazard". Time is relative to the first time a particular loan was taken out and resets when this loan is considered repaid. Loan is considered repaid when more than 80% of the current loan is not rolled over or when the bank does not take out loan within five calendar days of the last repayment. The sample includes institutions accessing the discount window facilities during the crisis. All variables are allowed to change daily and multiple events are allowed for single institution. All regressions include Federal Reserve district indicators and indicators denoting the frequency of accounting data. (q) and (d) denotes the quarterly and daily measurement frequency relative to the loan initiation. ***, **, * denotes statistical significance at the 1%, 5%, and 10% level, respectively.

	8/21/2007–9/15/2008 (Pre-Lehman)			9/16/2008–6/30/2009 (Post-Lehman)		
	1	2	3	4	5	6
S-T debt / TA (q–1)	–0.84	–0.84	–0.68	0.32	0.61	0.57
	(0.48)	*(0.48)*	*(0.55)*	*(0.82)*	*(0.63)*	*(0.66)*
Deposits / TA (q–1)	–0.46	–0.46	–0.50	–1.00	–0.55	–0.41
	(0.62)	*(0.62)*	*(0.58)*	*(0.43)*	*(0.64)*	*(0.73)*
FHLB advances / TA	–1.09	–1.09	–1.12	–0.61	–0.43	–0.53
	(0.38)	*(0.38)*	*(0.34)*	*(0.68)*	*(0.75)*	*(0.69)*
Equity / TA (q–1)	–0.40	–0.40		–0.37		
	(0.91)	*(0.91)*		*(0.90)*		
ROA (q–1)	9.46	9.46		2.29		
	(0.58)	*(0.58)*		*(0.73)*		
Non–Perf. loans / TA (q–1)	1.52	1.52		1.23		
	(0.84)	*(0.84)*		*(0.39)*		
MB (d–1)	0.96	0.96		2.72		
	(0.43)	*(0.43)*		*(0.10)*		
Insolvency index (d)					–0.08	
					(0.23)	
Z score			0.0001			0.0013
			(0.83)			*(0.14)*
End-of-quarter indicator (d)	–0.26	–0.26	–0.24	0.74***	0.72***	0.71***
	(0.54)	*(0.54)*	*(0.57)*	*(0.00)*	*(0.00)*	*(0.00)*
Foreign institution indicator	0.26	0.26	0.26	0.84	0.86	0.99
	(0.39)	*(0.39)*	*(0.30)*	*(0.29)*	*(0.27)*	*(0.20)*
Total assets (q–1) [trillions]	–0.01	–0.01	–0.03	–0.25	–0.25	–0.25
	(0.96)	*(0.96)*	*(0.90)*	*(0.59)*	*(0.57)*	*(0.58)*
TARP balance indicator (q)				0.15	0.09	0.11
				(0.28)	*(0.49)*	*(0.41)*
Forced TARP indicator				0.45	0.36	0.48
				(0.47)	*(0.57)*	*(0.44)*
S&P 500 return (d)	0.13	0.13	0.31	–3.48*	–3.45*	–3.52*
	(0.98)	*(0.98)*	*(0.95)*	*(0.07)*	*(0.07)*	*(0.07)*
Pr(Likelihood ratio)	0.92	0.92	0.89	0.08	0.04	0.04
Observations total	1,409	1,409	1,409	2,121	2,121	2,121
Observations with event	327	327	327	283	283	283

While Fig. 1 suggests this is the case, Figs. 3 and 5 show a sharp drop-off in DW and PDCF borrowing before the end of the last quarter of 2008. By late December only three primary dealers had PDCF debt outstanding: Morgan Stanley, Merrill Lynch, and Citigroup.[26] We note that the identity of the borrowers from these programs was not made public until after the Fed lost the Bloomberg FOIA lawsuit and that the publicly traded firms did not list these loans in detail in their SEC filings. We therefore examine the propensity to repay DW and PDCF debt in hazard function estimations in Tables 9 and 10.

Table 9 models the probability of repaying a DW loan using a multiple event hazard function estimation. Hypotheses H1A, H2A and H3A imply that firms with more ST debt would struggle to repay the Fed debt, especially after Lehman, and would continue to roll over the loans until the crisis pressure subsided. In contrast, if the bailout framework describes borrowing more accurately, firms with a greater fraction of bad loans and a lower capital base would continue to use the programs as the market penalizes them for being closer to insolvency (making the Fed's penalty rate less onerous for them). Table 9 shows that all of the variables are insignificant. Interestingly, during the post-Lehman period, institutions were significantly more likely to prepay DW loans as the quarter end approached, lending support to the bailout loan repayment hypothesis. This result may also suggest that frozen debt markets thawed before December 31, 2008 as banks sought to repay DW loans before the quarter end. The desire to prepay DW loans may further reflect the increased availability of deposits for banks.

Table 10 reports the same estimations for primary dealers borrowing from PDCF. Among these firms, the end of quarter variable is significantly positive in the pre-Lehman but not in the post-Lehman period. The insolvency index coefficient is significantly negative in the pre-Lehman period, indicating that more insolvent firms are less likely to prepay loans.

The end of the quarter is likely to be more important for banks that borrow a large amount from the government, as banks with smaller loans may avoid disclosure on the basis that the information is not material. In untabulated results, we find that only a few firms borrowed amounts exceeding 30% of their equity from the Fed.[27] In total, only 14 banks and 5 dealers ever borrowed such a

[26] Since Bank of America announced the takeover of Merrill Lynch in September, its PDCF debt could easily have been associated with the merger, as has often been the case with DW and PDCF borrowing in the crisis. If so, the decline in LOLR lending through the PDCF was even sharper.

[27] Our reference to the cutoff of 30% of equity reflects SEC guidance on reporting short-term debt (U.S. SEC Industry Guide at https://www.sec.gov/about/forms/industryguides.pdf). Specifically, p. 12 states: "VII. *Short-Term Borrowings*
For each reported period, present the following information for each category of

Table 10
Hazard model: PDCF loan repayment.
Institutions repaying/not rolling over a PDCF loan are classified as experiencing an "event/hazard". Time is relative to the first time a particular loan was taken out and resets when this loan is considered repaid. Loan is considered repaid when more than 80% of the current loan is not rolled over or when the institution does not take out loan within five calendar days of the last repayment. The sample includes institutions accessing the PDCF facilities during the crisis. Corporate Instruments Collateral Indicator equals one if the collateral pledged contains unsecured securities issued by private corporations. All variables are allowed to change daily. (q) and (d) denotes the quarterly and daily measurement frequency relative to the loan initiation. ***, **, * denotes statistical significance at the 1%, 5%, and 10% level, respectively.

	3/17/2008–9/15/2008 (Pre-Lehman)			9/16/2008–6/30/2009 (Post-Lehman)		
	1	2	3	4	5	6
S-T debt / TA (q–1)	5.64	2.86	11.18*	–34.34	–25.45	–27.07
	(0.23)	*(0.46)*	*(0.08)*	*(0.16)*	*(0.12)*	*(0.11)*
Deposits / TA (q–1)	–16.59	–23.76	–9.00	–13.43	0.70	4.63
	(0.45)	*(0.26)*	*(0.64)*	*(0.45)*	*(0.93)*	*(0.64)*
Equity / TA (q–1)	101.91			–486.16		
	(0.18)			*(0.12)*		
ROA (q–1)	140.64			872.84		
	(0.29)			*(0.47)*		
MB (d–1)	115.27**			–185.23		
	(0.03)			*(0.21)*		
Insolvency index (d)		–1.63**			–0.48	
		(0.02)			*(0.53)*	
Z score			–0.05			–0.08
			(0.18)			*(0.47)*
End-of-quarter indicator (d)	3.59**	4.08**	4.02**	8.01	1.54	1.97
	(0.03)	*(0.01)*	*(0.01)*	*(0.36)*	*(0.40)*	*(0.33)*
Foreign institution indicator	12.42	8.15	3.78	–6.02	1.30	1.12
	(0.10)	*(0.18)*	*(0.49)*	*(0.49)*	*(0.55)*	*(0.66)*
Total assets (q–1) [trillions]	–1.93	–0.02	1.15	–6.76*	–4.62	–5.32*
	(0.16)	*(0.98)*	*(0.16)*	*(0.10)*	*(0.10)*	*(0.08)*
Arbitrage possible in TSLF				18.17	16.38	16.84
				(1.00)	*(1.00)*	*(1.00)*
TARP balance indicator (q)				30.13	1.78	2.32
				(0.11)	*(0.59)*	*(0.44)*
Pr(Likelihood ratio)	0.04	0.02	0.14	0.03	0.19	0.18
Observations total	152	152	152	383	383	383
Observations with event	16	16	16	10	10	10

high fraction from the Fed, and all but a handful of these firms had either already failed or were about to be merged into a stronger bank.

Overall, the prepayment patterns indicate that firms avoided reporting Fed loans at the end of a quarter as part of a strategy to avoid the effects of revealing poor financial health. For primary dealers, solvency concerns during pre-Lehman period played a significant role in loan prepayments. These results are consistent with the bailout loan prepayment hypothesis.

3. Conclusion

The Federal Reserve introduced a number of emergency loan programs in the most recent financial crisis in its role as lender of last resort in an attempt to improve market liquidity. In this paper we analyze the loan micro data to assess whether the new programs were more effective in providing liquidity in a crisis than the DW program that had been associated with stigma in previous periods. The stigma reputation likely arose from a past Fed habit of lending to weak or already failed institutions. Hence, we also consider whether the programs more often amounted to backdoor bailouts of weak institutions.

We find that the amount lent through the programs increased dramatically during the crisis, which suggests the institutions avoided the stigma of the discount window. However, the total amount outstanding was at most 15% of the total amount of short-term debt of institutions in our sample. Meanwhile, comparable amounts of funds were also supplied by the FHLB system. Throughout the crisis, private debt markets supplied over 80% of the short-term debt used by the institutions in our sample. Furthermore, while emergency program usage became more widespread after the Lehman bankruptcy, the results reveal a high concentration of borrowers even in the most severe part of the crisis. We also find that only a small fraction of banks and a handful of primary dealers ever borrowed as much as 30% of their equity at one time. Given their very high leverage, this means that the majority of their assets were funded by sources other than the emergency facilities.

We attribute the low level of borrowing from Fed facilities at least somewhat to the high cost of borrowing. Previous research and our analysis indicate that most large commercial banks and many of the primary dealers had ample access to deposits during the crisis. Since these funds were less expensive than secured debt with a penalty rate, commercial banks would naturally rely on them more in a crisis. Our evidence also suggests that FHLB loans were often more appealing, although they are not available to all the banks in our sample. Finally, as long as banks had access to secured funding in the crisis from private markets, they had little incentive to borrow from the DW or PDCF at the Fed's penalty rates. We note that Fed borrowing was not often backed with typ-

short-term borrowings reported in the financial statements pursuant to §210.0-04.11: (1) The amounts outstanding at the end of the reported period, the weighted average interest rate thereon, and the general terms thereof; (2) The maximum amount of borrowings in each category outstanding at any month-end during each reported period; (3) The approximate average amounts outstanding during each reported period and the approximate weighted average interest rate thereon. *Instruction.*This information is not required to be given for any category of short-term borrowings for which the average balance outstanding during the period was less than 30 percent of stockholders' equity at the end of the period."

Table A.1
Overview of federal reserve facilities during subprime crisis.

	Start date	End date	Maturity	Notes
Commercial banks:				
DW: Primary/Secondary credit	8/17/2007		Maturity extended to 30 days	
	3/16/2008		Maturity extended to 91 days	
TAF	12/12/2007	4/8/2010	28 and 84 days	May not be prepaid. Primary credit institutions.
Primary dealers:				
PDCF	3/17/2008	2/1/2010	Overnight	
TSLF – Schedule 1	3/27/2008	7/1/2009	28 days	May not be prepaid.
TSLF – Schedule 2	3/27/2008	2/1/2010	28 days	May not be prepaid.

ical repo market collateral after Lehman, and instead involved a large fraction of corporate bonds and equity.

While the Fed program borrowing is at a penalty rate, this penalty rate does not take into account firm-specific (solvency) characteristics. This makes the debt relatively more desirable to undercapitalized banks. Even the auction programs, which do not set rates and have no penalty, encourage weaker banks to bid more aggressively for funds, again making the relative cost of the Fed loans lower for banks that are closer to insolvency. Furthermore, we find that weaker banks were more likely to borrow from the Fed after Lehman declares bankruptcy, including Lehman itself. Our analysis of factors affecting DW and PDCF loan prepayments also suggests that banks repaid the loans in order to avoid negative information revealed through SEC filings.

In addition to the fact that the programs replaced only a small portion of the firms' short-term debt, much of that low fraction owed to loans that were unrelated to market conditions. Some of the largest individual loans were made to foreign firms that had already failed, such as Dexia and Depfa. The timing of several large loans coincides with a merger, such as JPMorgan's acquisition of Bear Stearns, and not the result of market freezes. Considering these loans, the programs were even less likely to relieve roll-over pressures in short-term debt markets.

Overall, we conclude that the programs added liquidity to debt markets at a time when they were stressed. However, the added liquidity was quite limited and it often went to institutions in danger of a bailout or firms that already received one. We conjecture that they could add more liquidity in a future crisis if the penalty rates were no longer applied.

Appendix

A.1. Fed lending pre- and post-2007

Prior to the start of the crisis, the Fed's emergency lending facilities consisted solely of overnight lending to commercial banks via the discount window. The penalty at that point was set at 100 basis points (bp) above the FF rate. Starting with the "quant shock" in August 2007 (Khandani and Lo,2007), the Fed modified the DW to expand its LOLR role and subsequently introduced several new programs. It also reduced the penalty to 50 bp.Appendix Table A.1 summarizes the main borrowing facilities analyzed in this paper available to large financial institutions during the crisis and Fig. A.1 shows a timeline that relates them to events in the markets. An important change to its approach occurred in March 2008 after the Bear Stearns bailout, when the Fed opened the discount window to large investment banks (the primary dealers) via the PDCF and reduced the penalty further to only 25 bp above the target FF rate. The rules for PDCF loans were identical to those for commercial banks using the discount window – the loans were short-term (ST), mostly overnight (although by that point up to a maturity of 90 days), secured, and offered immediately to any firm that requested the money, no questions asked as to why the cash was necessary.[28] Both facilities made a distinction between primary and secondary credit, with the former meant for sound

Table A.2
Timeline of TAF program: 12/12/2007–12/31/2008.

Date	Event/Notes
12/12/2007	The Fed announces creation of Term Auction Facilty (TAF).
12/20/2007	First TAF auction - total amount made available: $20 billion.
12/27/2007	TAF total available amount increased to $40 billion.
1/17/2008	TAF total available amount increased to $50 billion.
1/24/2008	TAF total available amount decreased to $30 billion.
1/31/2008	TAF total available amount increased to $60 billion.
3/7/2008	TAF program extended for at least 6 months.
3/13/2008	TAF total available amount increased to $80 billion.
3/27/2008	TAF total available amount increased to $100 billion.
5/8/2008	TAF total available amount increased to $125 billion.
5/22/2008	TAF total available amount increased to $150 billion.
7/30/2008	Introduction of 84-day TAF loans.
10/9/2008	TAF total available amount increased to $275 billion.
10/23/2008	TAF total available amount increased to $350 billion.
11/6/2008	TAF total available amount increased to $475 billion.
12/4/2008	TAF total available amount increased to $600 billion.
12/22/2008	TAF total available amount increased to $750 billion.
12/23/2008	TAF total available amount increased to $900 billion.

Source: http://timeline.stlouisfed.org/index.cfm?p=timeline. http://www.federalreserve.gov/monetarypolicy/taf_2007.htm.

Table A.3
Timeline of TLSF program: 3/11/2008–12/31/2008.

Date	Event
3/11/2008	The Fed announces creation of Term Securities Lending Facilty (TSLF).
3/28/2008	First TSLF auction - total amount made available: $75 billion.
4/4/2008	TSLF total available amount increased to $100 billion.
4/11/2008	TSLF total available amount increased to $150 billion.
4/18/2008	TSLF total available amount increased to $175 billion.
5/2/2008	Eligible collateral for Schedule 2 expanded to include AAA/Aaa-rated ABS.
7/30/2008	TSLF extended through 1/30/2009.
9/14/2008	Eligible collateral for Schedule 2 expanded to include investment-grade debt securities. Schedule 2 auction frequency increased.
9/18/2008	TSLF total available amount increased to $245 billion.
9/26/2008	TSLF total available amount decreased to $232.5 billion.
10/10/2008	TSLF total available amount decreased to $195 billion.
10/16/2008	TSLF total available amount increased to $197.5 billion.
10/30/2008	TSLF total available amount increased to $200 billion.
11/25/2008	TSLF total available amount decreased to $175 billion.
11/28/2008	TSLF total available amount increased to $200 billion.
12/2/2008	TSLF extended through 4/30/2009.

Source: http://timeline.stlouisfed.org/index.cfm?p=timeline. http://www.newyorkfed.org/markets/tslf/termseclending_Historical.cfm.

[28] Madigan and Nelson (2002) discuss changes to the DW that were designed to reduce the stigma, including the elimination of the requirement that the borrower

Table A.4
Timeline of selected key events: 12/12/2007–12/31/2008.

Date	Event
12/12/2007	The Fed announces Term Auction Facilty (TAF).
12/12/2008	The Fed announces $20 billion and $4 billion swap lines for 6 months with European Central Bank and the Swiss National Bank, respectively.
12/20/2007	First TAF auction - total amount made available: $20 billion.
2/17/2008	Northern Rock nationalized by UK Treasury.
3/11/2008	The Fed announces Term Securities Lending Facilty (TSLF).
3/11/2008	The Fed increases swap lines with European Central Bank and the Swiss National Bank by $10 billion and $2 billion, respectively. Both swap lines extended through 9/30/2008.
3/16/2008	Merger announcement: JPM-Chase to acquire Bear Stearns.
3/16/2008	The Fed announces Primary Dealer Credit Facility (PDCF).
3/24/2008	The Fed provides financing to JPM-Chase for acquisition of Bear Stearns.
3/27/2008	TAF total available amount increased to $100 billion.
3/28/2008	First TSLF auction - total amount made available: $75 billion.
5/2/2008	The Fed increases swap lines with European Central Bank and the Swiss National Bank by $20 billion and $6 billion, respectively.
5/8/2008	TAF total available amount increased to $125 billion.
5/29/2008	Bear Stearns acquisition approved by shareholders.
7/11/2008	IndyMac Federal Bank seized by regulators (largest thrift failure to-date).
7/15/2008	SEC issues order to temporarily suspend naked short-selling of Fannie Mae, Freddie Mac, and primary dealers.
7/30/2008	The Fed increases swap line with European Central Bank to $55 billion.
9/7/2008	Fannie Mae and Freddie Mac taken over by the U.S. government.
9/14/2008	Merger announcement: Bank of America to acquire Merrill Lynch.
9/14/2008	The Fed expands the list of eligible collateral for PDCF and TSLF.
9/15/2008	Lehman Brothers Inc. Files for bankruptcy.
9/16/2008	Barclays to acquire Lehman Brothers Inc.
9/16/2008	$85 billion AIG bailout by U.S. government.
9/17/2008	SEC issues order to temporarily suspend naked short-selling of financial institutions.
9/18/2008	The Fed increases swap lines by $180 billion and authorizes new swap lines with Bank of Japan, Bank of England, and Bank of Canada.
9/18/2008	Merger announcement: Lloyds TSB to acquire Bank of Scotland.
9/21/2008	Goldman Sachs and Morgan Stanley convert to bank holding companies.
9/24/2008	The Fed establishes swap with the Reserve Bank of Australia ($10 billion), the Sveriges Riskbank ($10 billion), Norges Bank ($5 billion), and Danmarks Nationalbank ($5 billion) through 1/30/2009.
9/25/2008	Washington Mutual closed by regulators (sold to JPM-Chase).
9/26/2008	The Fed increases swap lines with European Central Bank and the Swiss National Bank by $10 billion and $3 billion, respectively.
9/28/2008	Partial nationalization of Fortis by governments of Benelux countries.
9/29/2008	First bailout proposal of Depfa announced.
9/29/2008	The Fed expands swap lines by $330 billion to a total of $620 billion.
9/30/2008	Dexia bailed out by governments of Belgium and France.
10/3/2008	Merger announcement: Wells Fargo to acquire Wachovia.
10/3/2008	Congress passes TARP.
10/6/2008	Depfa's holding company bailed out by German government.
10/7/2008	FDIC announces increase in deposit insurance coverage to $250,000.
10/8/2008	Additional $37.8 billion AIG bailout by U.S. government.
10/9/2008	TAF total available amount increased to $275 billion.
10/13/2008	Bank of Scotland bailed out by UK Treasury.
10/13/2008	Recapitalization of Royal Bank of Scotland by UK government.
10/13/2008	The Fed increases swap line with European Central Bank, Bank of England, and Swiss National Bank.
10/14/2008	The Fed increases swap line with Bank of Japan.
10/28/2008	First TARP transactions.
10/28/2008	The Fed establishes swap line with Reserve Bank of New Zealand ($15 billion).
10/29/2008	The Fed establishes swap lines with Banco Central de Brasil, Banco de Mexico, Bank of Korea, and Monetary Authority of Singapore; $30 billion each.
11/10/2008	AIG bailout restructured to include TARP and the creation of Maiden Lane facilities.
12/5/2008	Merrill Lynch acquisition approved by shareholders.
12/31/2008	Wells Fargo acquisition of Wachovia completed.

Sources: http://timeline.stlouisfed.org/index.cfm?p=timeline.
TARP data

institutions. In our data we see no such distinction and thus we refer to the two types of loans as if they were the same.

In contrast to the DW and PDCF, the TAF and TSLF were longer maturity programs that lent money at regularly scheduled intervals to the winners of an auction. The TAF began in December 2007 as

show evidence that other sources of funding were unavailable and therefore that the Fed was truly its last resort.

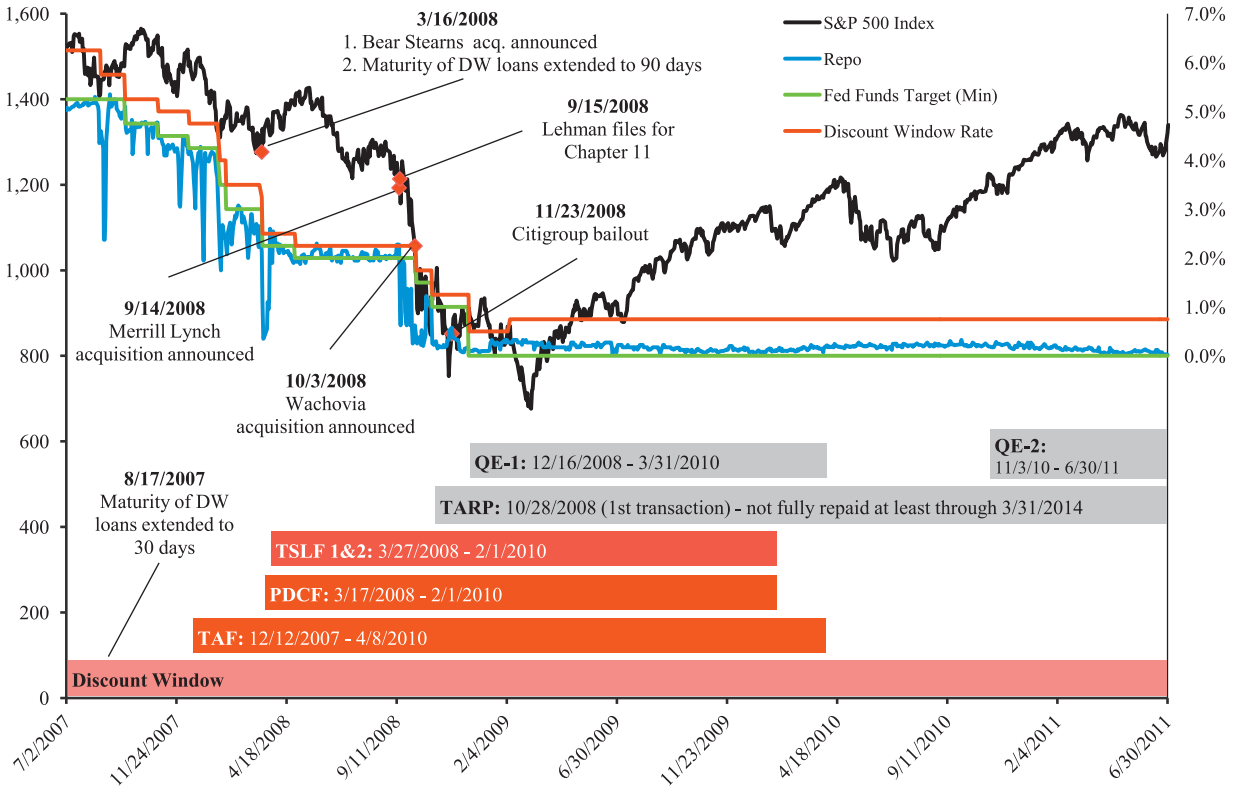


Fig. A.1. S&P 500 Index, Target Fed Funds, Fed's Liquidity Programs, TARP, QE, and Relevant Events: July 2007 – June 2011.

a means of supplying additional liquidity to commercial banks.[29] The TAF was a biweekly auction of 28-day loans, where no bidder could obtain more than ten percent of the auction total and the rate charged was determined by the bidding. Initially, the program lent up to $20 billion but it was expanded to $900 billion later when the crisis worsened. Unlike the DW and PDCF loans, a TAF loan could not be paid back prior to maturity. Likewise, the TSLF was also a biweekly auction of secured loans with 28-day maturities, but the TSLF auctions offered up to $245 billion of loans to primary dealers.

Of the four programs, only the DW facility lasted beyond 2010. These emergency facilities were considered temporary, for use in a crisis, and thus were considered unnecessary by early 2010. For similar reasons, the penalty on DW loans was reset to 100 bp in 2010.

The Fed also introduced four other programs. However, these programs would not be considered methods for a LOLR to provide funding to financial institutions in a crisis and thus we do not match up their use to data on a specific commercial bank or primary dealer. The CPFF was instituted in October 27, 2008 to purchase commercial paper (CP) directly from issuers. The AMLF, which began on September 19, 2008, purchased asset-backed CP from money market mutual funds (see Duygan-Bump et al., 2013). A complementary program, the MMIF, was also intended as a way to buy CP. The TALF was a debt guarantee program. We ignore these programs because they were either not restricted to financial institutions (CPFF and TALF) or were restricted to a set of financial institutions that did not borrow from potentially frozen credit markets (AMLF and MMIF).

A.2. Loan data

In response to an FOIA lawsuit by Bloomberg News, the Fed produced data on its lending activities during the crisis. With respect to DW, two types of electronic documents were produced for each day during the crisis: The first document shows loan initiations on that day; the second shows all loans outstanding.[30] We collect information on the date the loan starts, how long it remains outstanding, its maturity date, the borrower's name, the type of institution, and its Federal Reserve district from the second set of documents and cross-check these data with the documents on loan initiations. The Fed classified institutions into seven categories, with the majority of institutions fitting into the categories of Large Money Center Bank (LMCB), Other Large Commercial Bank (OLCB), Small Commercial Bank, Thrift or Credit Union, and Foreign.

We obtain information on TAF, PDCF, and TSLF borrowing from the Fed's website.[31] Files for each facility include the date the loan is initiated, its maturity date, the institution's name, the amount of the loan, its interest rate, and various items about pledged collateral.

While all four of the programs were intended to provide liquidity to financial institutions in an emergency, the features of the liquidity facilities differed in a number of ways. Thus, we investigate the separate use of the facilities as well as the aggregate use. The DW and the TAF are aimed at commercial banks. However, the TAF has limited funding, in terms of both the frequency of the auctions and the size of the program, while the DW offers

[29] Goldman and Morgan Stanley converted to bank holding companies on September 22, 2008, making them eligible for both the DW and TAF on that date. Lehman was able to borrow from the DW through its bank subsidiary but not the TAF.

[30] The Fed produced more than 29,000 pages of documents related to the Bloomberg's FOIA lawsuit (all documents pertaining to DW borrowing were released as Acrobat files). The original electronic files produced by the Fed were obtained at:cdn.gotraffic.net/downloads/30110331_fed_release_documents.zip.

[31] http://www.federalreserve.gov/newsevents/reform_transaction.htm.

the borrower immediate access to funds at any point in time. The PDCF and the DW are identical in the terms of their loans, but the PDCF is for primary dealers only and it does not start until after the announcement of the Bear Stearns acquisition. However, by the fourth quarter of 2008 most of the large primary dealers are bank holding companies and eligible for DW loans. Lastly, the TSLF lowered its requirements on collateral after Lehman's bankruptcy, likely affecting the choice of which program to borrow from in late 2008.

References

Acharya, V.V., M.J. Fleming, W.B. Hrung, and A. Sarkar. 2014. Dealer financial conditions and lender-of-last resort facilities. Working paper.

Afonso, G., Kovner, A., Schoar, A., 2011. Stressed, not frozen: the federal funds market in the financial crisis. J. Finance 66, 1109–1139.

Andersen, P.K., Gill, R.D., 1982. Cox's regression for counting processes: a large sample study. Ann. Stat. 10, 110–1120.

Armantier, O., E. Ghysels, A. Sarkar, and J. Shrader. 2011. Stigma in financial markets: evidence from liquidity auctions and discount window borrowing during the crisis. Working paper.

Artuc, E., Demiralp, S., 2010. Discount window borrowing after 2003: the explicit reduction in implicit costs. J. Bank. Finance 34, 825–833.

Ashcraft, A., Bech, M.L., Frame, W.S., 2010. The federal home loan bank System: the lender of Next-to-Last resort. J. Money Credit Bank. 42, 551–583.

Bagehot, W., 1873. Lombard Street: A Description of the Money Market, London, In: King Henry S., (Ed), 3rd edition, http://oll.libertyfund.org/titles/128.

Benmelech, E., Bergman, N.K., 2009. Collateral pricing. J. Financ. Econ. 91, 339–360.

Berger, A.N., L.K. Black, C.H.S. Bouwman, and J.L. Dlugosz. 2013. The federal reserve's discount window and TAF programs: "pushing on a string?" Working paper.

Boyd, J.H., Gertler, M., 1994. The role of large banks in the recent U.S. banking crisis. Fed. Res. Bank Minneapolis Q. Rev. 18, 2–21.

Boyson, N.M., Helwege, J., Jindra, J., 2014. Crises, liquidity shocks and fire sales at commercial banks. Financ. Manage. 43, 857–884.

Christensen, J.H.E., Lopez, J.A., Rudebusch, G.D., 2013. Do central bank liquidity facilities affect interbank lending Rates? J. Bus. Econ. Stat. *forthcoming*.

Copeland, A., A. Martin, and M. Walker. 2010. The tri-party repo market before the 2010 reforms. Working paper.

Cornett, M.M., McNutt, J., Strahan, P., Tehranian, H., 2011. Liquidity risk management and credit supply in the financial crisis. J. Financ. Econ. 101, 297–312.

Duygan-Bump, B., Parkinson, P., Rosengren, E., Suarez, G., Willen, P., 2013. How effective were the federal reserve emergency liquidity Facilities? Evidence from the asset-backed commercial paper money market mutual fund liquidity facility. J. Finance 68, 715–737.

Ennis, H.M., Weinberg, J.M., 2013. Over-the-counter Loans, adverse selection and stigma in the interbank market. Rev. Econ. Dyn. 16, 601–616.

Flannery, M., 1996. Financial crises, payment system problems, and discount window lending. J. Money Credit Bank. 28, 804–824.

Fleming, M.J., Hrung, W.B., Keane, F.M., 2009. The term securities lending facility: origin, design, and effects. Fed. Res. Bank New York Curr. Issues 15, 1–10.

Furfine, C., 2001. The reluctance to borrow from the fed. Econ. Lett. 72, 209–213.

Furfine, C., 2003. Standing facilities and interbank borrowing: evidence from the fed's new discount window. Int. Finance 6, 329–347.

Gatev, E., Schuermann, T., Strahan, P., 2009. Managing banks liquidity risk: how deposit-loan synergies vary with market conditions. Rev. Financ. Stud. 22, 995–1020.

Gatev, E., Strahan, P., 2006. Banks' advantage in hedging liquidity risk: theory and evidence from the commercial paper market. J. Finance 61, 867–892.

Gorton, G., Metrick, A., 2012. Securitized banking and the run on the repo. J. Financ. Econ. 104, 425–451.

Hrung, W.B., Seligman, J.S., 2015. Responses to the financial crisis, treasury debt, and the impact on short-term money markets. Int. J. Central Bank. 11, 151–190.

In, F., Cui, J., Maharaj, E.A., 2012. The impact of a new term auction facility on LIBOR–OIS spreads and volatility transmission between money and mortgage markets during the subprime crisis. J. Int. Money Finance 31, 1106–1125.

Khandani, A., Lo, A., 2007. What happened to the quants in august 2007? J. Invest. Manage. 5, 29–78.

Madigan, B., Nelson, W., 2002. Proposed revisions to the federal reserve's discount window lending programs. Fed. Res. Bull. 88, 314–319.

McAndrews, J., Sarkar, A., Wang, Z., 2008. The effects of the term auction facility on the London inter-bank offered rate. Fed. Res. Bull. 88, 314–319.

Peristiani, S., 1998. The growing reluctance to borrow at the discount window: an empirical investigation. Rev. Econ. Stat. 80, 611–620.

Price, D.A., 2012. When the fed conducts credit policy. *Fed. Reserve Bank Richmond Reg. Focus* First Q. 6–8.

Schwartz, A. 1992. The misuse of the fed's discount window. *Fed. Reserve Bank St. Louis Rev.* September–October:58–69.

Taylor, J.B., Williams, J.C., 2009. A black swan in the money market. Am. Econ. Assoc. J. Macroeconomics 1, 58–83.

Wu, T., 2011. The U.S. money market and the term auction facility in the financial crisis of 2007–2009. Rev. Econ. Stat. 93, 617–631.