



Dealer financial conditions and lender-of-last-resort facilities[☆]



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ABSTRACT

We examine the financial conditions of dealers that participated in two of the Federal Reserve's lender-of-last-resort (LOLR) facilities—the Term Securities Lending Facility (TSLF) and the Primary Dealer Credit Facility (PDCF)—that provided liquidity against a range of assets during 2008–2009. Dealers with lower equity returns and greater leverage prior to borrowing from the facilities were more likely to participate in the programs, borrow more, and, in the case of the TSLF, at higher bidding rates. Dealers with less liquid collateral on their balance sheets before the facilities were introduced also tended to borrow more. The results suggest that both financial performance and balance sheet liquidity play a role in LOLR utilization.

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1. Introduction

Central banks undertook unprecedented actions to mitigate the effects of the financial crisis of 2007–2009, with the Federal Reserve acting as lender of last resort (LOLR) to non-depository institutions for the first time since the 1930s. Evidence now exists to explain ways in which central bank liquidity provision relaxes institutions' funding constraints *ex post* and thereby improves prices of illiquid assets.¹ However, relatively little work has sought to understand the *ex ante* incentives of firms to participate in

¹ See, for example, Coffey, Hrungrung, and Sarkar (2009), Fleming, Hrungrung, and Keane (2010), Adrian, Kimbrough, and Marchioni (2011), Ashcraft, Garleanu, and Pedersen (2011), Campbell, Covitz, Nelson, and Pence (2011), Wu (2011), Rose and Spiegel (2012), Duygan-Bump, Parkinson, Rosengren, Suarez, and Willen (2013), and McAndrews, Sarkar, and Wang (2015). Fleming (2012) reviews many of these studies.

the facilities and pledge specific types of collateral.² In this paper, we attempt to fill this gap by studying dealer behavior in two of the Fed's LOLR facilities—the Term Securities Lending Facility (TSLF) and the Primary Dealer Credit Facility (PDCF)—that provided liquidity against a range of assets during 2008–2009.

The TSLF and PDCF were introduced to address the funding pressures faced by dealers emanating from the disruptions in short-term money markets. The TSLF, announced first, enabled dealers to swap less liquid collateral for more liquid Treasury collateral at a fee determined via auction. The liquid Treasury collateral obtained via the TSLF was easier to fund in the market for repurchase agreements (repo market) compared with the less liquid collateral on dealers' books. In Schedule 1 TSLF operations, allowable collateral was limited to Fed-eligible collateral, that is, Treasury securities, agency debt securities, and agency mortgage-backed securities (MBS). Allowable collateral for Schedule 2 TSLF operations was broader and became more expansive over time, consisting of Schedule 1 collateral plus all investment-grade debt securities after September 14, 2008. In contrast to the TSLF, the PDCF provided funds directly to dealers at a set rate and accepted lower quality collateral than the TSLF.

Our main finding is that the observed demand for liquidity of a dealer, as measured by the likelihood of participation in the facilities, the amount dealers sought to borrow, and the TSLF bidding rate, was greater for dealers with weaker financial conditions. Fig. 1 summarizes our results informally. The figure shows dealers' average borrowing from the facilities (over the period dealers borrowed from the PDCF, from March 17, 2008 until May 12, 2009) against their average cumulative equity return from the beginning of 2007.³ For each TSLF schedule type and for the PDCF, borrowing amounts tend to be higher for firms with worse equity performance.

In our formal tests, we proxy for the financial condition of a dealer at the time of a borrowing opportunity by two measures: (1) the cumulative equity return from a pre-crisis date (January 2, 2007), as in Fig. 1, and (2) the dealer's leverage, the ratio of quasi-market value of assets (market value of equity + book value of non-equity liabilities) to market value of equity. These measures are of particular interest because they reflect the market's assessment of firms' balance sheet conditions and, in particular, of their equity and equity relative to non-equity liabilities. In contrast, regulatory capital levels diverged significantly from market price-based measures during the crisis (Haldane, 2012) and, thus, were less informative of dealer's financial conditions (as we have verified). We find a statistically and economically significant effect of

these dealer financial conditions on demand for liquidity in the facilities, and we find that the effect is robust to controlling for time fixed effects, which account for, and which we show are related to, fluctuations in aggregate funding conditions.⁴

When we exploit the differing collateral eligibility across the two schedules of TSLF auctions, we find evidence that in Schedule 2 auctions, in which permissible collateral was of lower quality (especially after the collapse of Lehman Brothers on September 15, 2008), dealers with lower equity returns were more likely to participate in auctions and sought to borrow significantly larger amounts. This suggests that dealers with weaker financial conditions found it more attractive to borrow in facilities that accepted less liquid collateral, potentially because they faced greater private funding costs for such collateral.

One explanation for our findings is that weaker dealers had more illiquid collateral to finance given that solvency and liquidity problems often feed on each other (e.g., Rochet and Vives, 2004; Diamond and Rajan, 2005). We test for this possibility and find that dealers with greater proportions of non-Fed-eligible collateral on their balance sheet prior to the crisis were more likely to borrow from the TSLF and PDCF. Moreover, we find some evidence that illiquidity and financial conditions interact, especially for participation at the PDCF, the broader of the two facilities; that is, worse performing firms are more likely to borrow from the lender of last resort when they have more illiquid collateral.⁵

We also find that the demand for liquidity by a dealer was increasing in the average financial performance of all dealers at the time of a TSLF auction. In other words, the effect of a decrease in the performance of a dealer in the set of bidders was to depress participation by other dealers (and, as our earlier results show, to enhance its own demand for liquidity). Because the Fed auctioned a fixed and limited amount of Treasury collateral, this suggests that dealers with worse financial conditions crowded out dealers with better financial conditions at the TSLF. While lending through auctions has been proposed as a potential remedy for the stigma associated with central bank borrowing, the crowding-out result represents a limitation to this remedy as the greater price that weaker borrowers are prepared to pay for liquidity can deter the safer borrowers from participating.⁶

⁴ These results are consistent with those of Boyson, Helwege, and Jindra (2014), who find that among large banks and dealers, weaker firms, defined across a number of financial metrics, were more likely to borrow from the discount window, Term Auction Facility, PDCF, and TSLF.

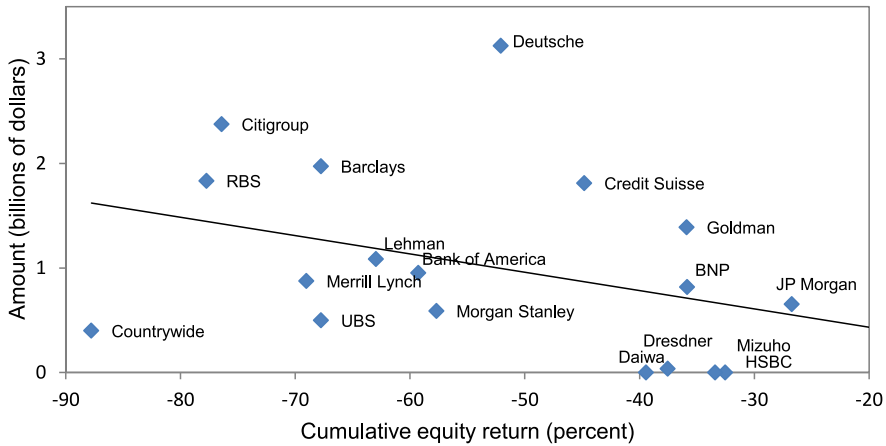
⁵ When we examine further potential interaction effects between borrowing in the TSLF and PDCF, we find that dealers who borrowed heavily in one facility tended to borrow heavily in the other. We also find that firms appear to have borrowed from the PDCF mainly because they needed funds in addition to what they could obtain from the TSLF (which auctioned fixed quantities of funds) and not because they valued the flexibility of shorter-term borrowing via the PDCF.

⁶ This crowding-out effect is reminiscent of the theoretical channel in the literature, e.g., Diamond and Rajan (2005), wherein banks with weaker financial conditions demand liquidity with greater immediacy. However, if the pool of liquidity is limited (as in a central bank auction in our setting), then the stronger liquidity demand of weaker banks precludes banks with relatively better financial conditions from having

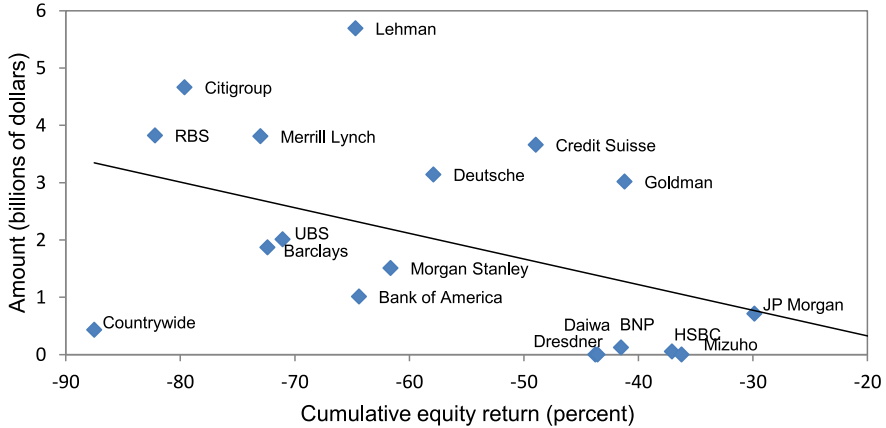
² An exception is Berger, Black, Bouwman, and Dlugosz (2016), who examine participation in the discount window and Term Auction Facility and find that weaker banks (as indicated by less capital and higher portfolio risk) were more likely to receive loans if the banks were small, but not if they were large.

³ The analysis excludes Bear Stearns, which agreed to be acquired by J.P. Morgan before either facility started operating. It also excludes Cantor Fitzgerald, which is not publicly traded. Lehman Brothers is included until its bankruptcy on September 15, 2008.

Panel A: TSLF Schedule 1 award amounts versus returns



Panel B: TSLF Schedule 2 award amounts versus returns



Panel C: PDCF borrowing amounts versus returns

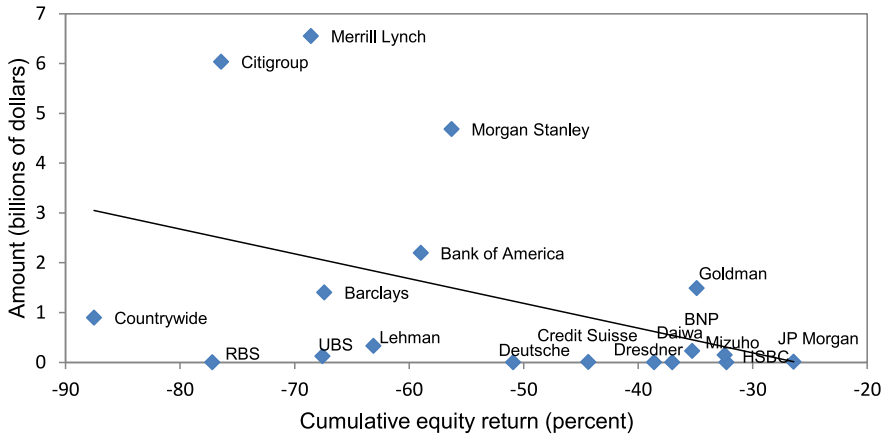


Fig. 1. Facility borrowing amounts versus returns. The figure plots dealers' average borrowing amounts from the Term Securities Lending Facility (TSLF)(Schedules 1 and 2) and Primary Dealer Credit Facility (PDCF) against their mean cumulative equity returns for the March 17, 2008 to May 12, 2009 sample period, excluding all activity for Bear Stearns and Cantor Fitzgerald and, for the period after September 15, 2008, Lehman Brothers. Averages are calculated over all operations, including those in which a given dealer did not borrow. Equity returns are cumulated from January 2, 2007 and then averaged over the sample period. The lines indicate the best fit for the scatter points.

While the funding difficulties faced by dealers reflected the performance and liquidity of their assets, they could have also reflected the structure of their liabilities. While data limitations preclude an extensive analysis of this issue, we do examine, for a subset of dealers, the relation between the financial condition measures we employ and the repo liabilities ratio, which is the ratio of the sum of securities sold to repurchase and fed funds borrowings to total liabilities. We focus on the period from early 2007 until the failure of Bear Stearns (as the extent of repo liabilities post-Bear Stearns would be affected by the TSLF and PDCF). A strong relation appears to exist, with worse performing dealers having higher ratios of repos to total liabilities.

Our results shed light on the lender-of-last-resort role played by central banks during aggregate liquidity shortages and panics. The associated literature suggests a trade-off between the ex post benefits of intervention and its ex ante costs. In his celebrated work, *Lombard Street*, Walter Bagehot (1873) codified the 19th century's collective wisdom on central bank provision of liquidity. Bagehot suggested that, in times of panic, the central bank should freely advance reserves to any private bank able to offer "what in ordinary times is reckoned a good security" as collateral, but that these advances should be charged a penalty rate to discourage applications from banks that do not need it. A rationale for such intervention by a central bank is that solvent but illiquid firms can inefficiently fail or engage in liquidations and fire sales in the absence of access to the lender of last resort.

While Bagehot was concerned primarily with the practical goal of conserving limited reserves, recent literature (see, especially, Diamond and Rajan, 2005) has stressed the incentive reasons for adopting such a policy. That is, telling the difference between an illiquid and an insolvent institution is not easy. In those circumstances, a central bank can easily find itself lending to an insolvent institution, perhaps delaying its timely reorganization and recapitalization. While lending at a penalty rate partially addresses this moral hazard concern, some (for instance, Acharya and Backus, 2009) have argued that central bank liquidity provision should be made conditional on adequate solvency estimates (such as a maximum leverage ratio or minimum capital adequacy) of financial institutions.⁷ Lack of such conditionality renders the central bank's provision of liquidity to weaker financial institutions a form of forbearance that can let the condition of these institutions

access to liquidity or makes it costlier for them to access liquidity. However, the relative lack of participation of stronger firms does not mean that such firms did not benefit from the facility if participation of weaker firms eased funding conditions and reduced the chances of fire sales more generally. Also, the TSLF imposed a 20% award limit at each auction, ensuring that liquidity could be supplied to at least five dealers.

⁷ Acharya and Backus (2009) draw an analogy with private lines of credit and recommend that central banks' liquidity facilities, like private lines of credit, include a Material Adverse Change (MAC) clause that allows the lender to refuse credit if the borrower's credit quality deteriorates materially. MAC clauses are invoked by banks in practice (see Sufi, 2009) for firms that violate covenants. Similarly, they recommend that central banks should verify that they are lending to sound institutions.

worsen, leading to zombie banks and further deepening a crisis.⁸

Our analysis, by showing the linkage between the participation of dealers in LOLR facilities and their relative financial performance, provides evidence consistent with the incentive reasons for Bagehot's recommendation, though it cannot provide a full welfare analysis of the overall effect of these facilities. While Bagehot and the moral hazard literature emphasize the need for restricting participation in LOLR programs to higher quality firms, asymmetric information considerations suggest that such restrictions need not be optimal. Flannery (1996) emphasizes that, during crisis periods, credit markets could fail due to the lemons problem and even solvent borrowers could be rationed or squeezed out. By lending at the breakeven pooling rate, LOLR facilities provide credit to some safe borrowers at the cost of also lending to risky borrowers. Philippon and Skreta (2012) examine cost-minimizing interventions when a bank's decision to participate in LOLR facilities reveals its type to private lenders. Optimal intervention involves the central bank lending to risky borrowers. However, weaker banks could be deterred from participation if the decision creates stigma by providing signals of asset quality to private lenders (Ennis and Weinberg, 2013; Philippon and Skreta, 2012).⁹

The rest of the paper is organized as follows. Section 2 provides background information on the PDCF and TSLF. Section 3 describes our data. Section 4 presents our main empirical results. Section 5 presents results of various additional analyses. Section 6 concludes.

2. The Term Securities Lending Facility and the Primary Dealer Credit Facility

Repurchase agreements (repos) play a crucial role in the efficient allocation of capital in financial markets. They are widely used by dealers to finance their market-making, risk management, and speculative activities, and they provide a safe and low-cost way for mutual funds, depository institutions, and others to lend funds. The importance of the repo market is suggested by its immense size. Primary dealers reported financing \$4.5 trillion in fixed income securities with repos as of March 4, 2008.

⁸ Evidence on the presence of such zombie banks lending to zombie firms, and inducing a credit crunch on others, is shown by Caballero, Hoshi, and Kashyap (2008) in the Japanese banking crisis of the 1990s and attributed to the Bank of Japan's forbearance and lack of required recapitalization of banks. Acharya and Tuckman (2014) develop a model showing that relatively distressed financial firms reduce the extent of sales of illiquid collateral eligible at the LOLR and shed more liquid collateral in private markets, thereby building up their illiquid leverage, a phenomenon they confirm empirically using evidence on balance sheets and LOLR usage of broker-dealer firms during the crisis of 2007–2008 (comparing the relatively more distressed Bear Stearns, Lehman Brothers, and Merrill Lynch to Goldman Sachs and Morgan Stanley).

⁹ Empirically, Hrug and Sarkar (2012) find that adverse selection measures such as the bid-ask spread were robust determinants of bank funding costs during the subprime and European debt crises. Further, discount window stigma appears to have dissuaded firms from borrowing central bank liquidity during the crisis, as shown by Armantier, Ghysels, Sarkar, and Shrader (2015).

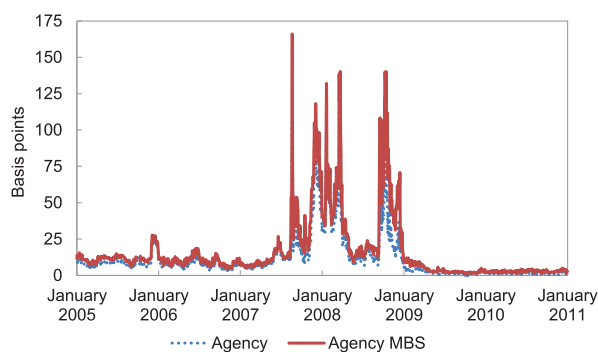


Fig. 2. Repo spreads. The figure plots one-month agency and agency mortgage-backed securities repo spreads to the one month Treasury general collateral repo rate.

2.1. Repo market conditions in 2008

While dealers normally rely on private markets to finance their positions, such markets became severely impaired in early 2008. Lenders of funds became increasingly concerned about losing money on repos because of worries about the value of the collateral as well as the credit risk of counterparties. Lenders responded by increasing haircuts (reducing the amount they were willing to lend for a given amount of collateral) and by halting lending against certain types of collateral altogether (Copeland, Martin, and Walker, 2010, 2014; Gorton and Metrick, 2012; Krishnamurthy, Nagel, and Orlov, 2014).

Another response was for lenders to demand greater compensation for lending against riskier collateral. As shown in Fig. 2, one month agency and agency MBS repo spreads to Treasury repo have historically been quite narrow, averaging 8 and 11 basis points between January 2005 and June 2007. That is, a dealer pledging agency debt securities as collateral has typically paid only slightly more interest to borrow funds than a dealer pledging Treasury securities. Such spreads widened out sharply as the financial crisis deepened, averaging 51 and 61 basis points, respectively, over January and February of 2008. Repo spreads for less liquid collateral are not widely available, but they were undoubtedly wider.

Disruptions in the ability of dealers to finance themselves in the repo market compel them to seek alternative sources of funding or to liquidate their positions. If a dealer cannot borrow elsewhere, and sales of securities are infeasible because of market illiquidity, a dealer could have to file for bankruptcy. It is widely reported that the inability of Bear Stearns to access the repo market was an important factor in its near collapse and purchase by J.P. Morgan Chase in March 2008 and in the failure of Lehman Brothers six months later.¹⁰

2.2. Introduction of the facilities

The TSLF and PDCF were introduced in this environment of funding market stress. The TSLF, announced March 11, 2008, allowed primary dealers to bid a fee to borrow Treasury securities from the Fed for a term of 28 days, while agreeing to provide less liquid securities as collateral (see Table 1). That is, collateral that can be difficult to finance could be temporarily swapped for Treasury collateral, which is easier to finance. The Fed announced it would lend up to \$200 billion in Treasury securities via this facility.

The PDCF, announced five days later, allowed primary dealers to borrow funds from the Fed on a daily basis at a set fee against designated collateral (see Table 1). The PDCF was more flexible than the TSLF because it provided funds instead of Treasury collateral, because it allowed for a broader range of collateral, and because it was available on a standing basis, with no set borrowing limit. The PDCF was thus similar to the Fed's discount window, which serves as a backstop source of liquidity for depository institutions.

The new facilities increased the ability of dealers to obtain financing, especially dealers relying on the repo market for financing of less liquid collateral. The ability of dealers to obtain financing through the facilities should have reduced the need for dealers to sell assets into illiquid markets to raise capital, potentially improving the liquidity of those markets. The ability to finance through the facilities should also have reduced funding pressures on dealers, lessening the likelihood of a loss of confidence among lenders.

While the TSLF was uniformly less flexible than the PDCF, its allocation of liquidity via auction could have been more effective at overcoming the perceived stigma that is thought to affect borrowing from the Fed's standing facilities (see, for example, Armantier, Ghysels, Sarkar and Shrader, 2015). The stigma arises from the concern that adverse inferences will be drawn about a firm's creditworthiness if its borrowing were to become known.¹¹ Auction facilities can overcome this stigma because they allow dealers to approach the Fed collectively instead of individually and because borrowing rates are set at auction and not at a premium by the Fed.¹²

A further advantage of the TSLF over the PDCF, as explained in Fleming, Hrungr, and Keane (2010), is that it did not directly affect the implementation of interest rate policy. In particular, the TSLF had no impact on the supply of bank reserves because it involved the exchange of securities for securities. In contrast, the PDCF did affect the supply of bank reserves because it involved the exchange of securities for cash. It follows that the Fed did not need

¹⁰ See, for example, Wall Street Journal (2008) and Financial Times (2008).

¹¹ As with the discount window, the names of borrowers are not revealed by the Fed in real time. Moreover, until after the crisis, borrower names were never revealed, even with a delay. Nonetheless, stigma is thought to exist because of a view that market participants are able to gather some information about who borrows from the Fed.

¹² Armantier, Krieger, and McAndrews (2008) make this point in their discussion of the Fed's Term Auction Facility, established in December 2007 to allocate funds to depository institutions via auction.

Table 1

Term Securities Lending Facility (TSLF) and Primary Dealer Credit Facility (PDCF) characteristics.

The table summarizes the key terms of the Term Securities Lending Facility and the Primary Dealer Credit Facility. Eligible collateral for the TSLF varied between Schedule 1 and Schedule 2 auctions. For Schedule 1, eligible collateral was composed of securities eligible in the Fed's open market operations [i.e., Treasury securities, agency securities, and agency mortgage-backed securities (MBS)]. Schedule 2 collateral originally was composed of Schedule 1 collateral plus AAA/Aaa-rated non-agency residential MBS, commercial MBS, and agency collateralized mortgage obligations (CMOs). Schedule 2 collateral was expanded to include AAA/Aaa-rated asset-backed securities beginning with the May 8, 2008 auction and all investment-grade debt securities beginning with the September 17, 2008 auction. Eligible collateral for the PDCF originally was composed of Fed-eligible collateral plus investment-grade corporate securities, municipal securities, mortgage-backed securities, and asset-backed securities. PDCF-eligible collateral was expanded to include all collateral eligible for tri-party repo, including non-investment grade securities and equities, after September 14, 2008. TSLF Schedule 1 auctions were held every two weeks beginning April 3, 2008 and ending June 25, 2009. TSLF Schedule 2 auctions were held every two weeks from March 27, 2008 through September 11, 2008, then weekly through April 22, 2009, then every two weeks again through July 16, 2009, then every four weeks through December 3, 2009, with a final auction five weeks later on January 7, 2010. The PDCF was open daily from March 17, 2008 to February 1, 2010.

Characteristic	Term Securities Lending Facility	Primary Dealer Credit Facility
Opening (first operation) date	March 27, 2008	March 17, 2008
Closing date	February 1, 2010	February 1, 2010
What the program did	Offered Treasury general collateral against eligible collateral	Offered funds against eligible collateral
Interest rate	Set by auction, with minimum fee	Discount window primary credit rate
Loan term	28 days	Overnight
Eligible borrowers	Primary dealers	Primary dealers
Eligible collateral	Investment-grade debt securities (for Schedule 2 operations after September 14, 2008)	All collateral eligible for tri-party repo (after September 14, 2008)
Operation frequency	Periodic	Daily

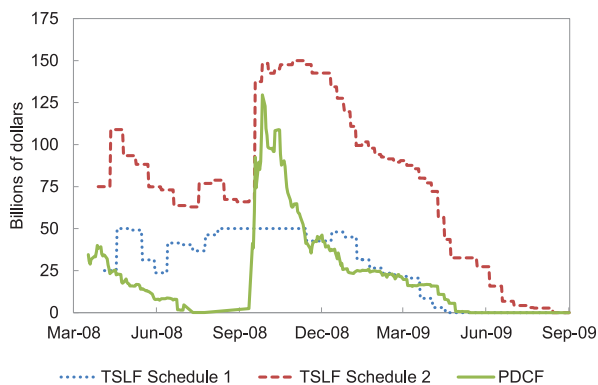


Fig. 3. Amounts outstanding. The figure plots amounts outstanding over time for the Term Securities Lending Facility (TSLF) (by schedule) and Primary Dealer Credit Facility (PDCF). The last TSLF auction was held January 7, 2010, but there was no borrowing after the July 16, 2009 auction. The PDCF was open until February 1, 2010, but there was no borrowing after May 12, 2009.

to add or drain reserves in response to TSLF operations to maintain reserves at their desired level, whereas it did need to react in response to PDCF borrowings.

The TSLF grew quickly after its inception, with an initial auction size of \$75 billion. Fig. 3 shows that the program (Schedule 1 and Schedule 2 combined) reached nearly \$160 billion outstanding within a month and peaked at the program's maximum announced size of \$200 billion in late October to early November 2008.¹³ As funding markets improved, utilization declined and lending under the facility wound down to zero by mid-August 2009. Authorization

¹³ We do not consider the TSLF Options Program, through which the Fed auctioned options allowing dealers to borrow Treasury securities via the TSLF. Over the course of the program, the Fed held six auctions for options with five exercise dates. Dealers exercised options on three occasions, with a maximum amount exercised of \$47.2 billion.

for lending under the TSLF officially expired on February 1, 2010.

Unlike the TSLF, the PDCF was used sparingly prior to the Lehman bankruptcy, with initial borrowing amounts of less than \$40 billion (see Fig. 3). After Lehman, borrowing amounts rose sharply to a peak of almost \$130 billion in late September 2008, before tailing off gradually for the remainder of the program.¹⁴ Authorization for lending under the PDCF expired on February 1, 2010, the same date as the expiration of the TSLF.

2.3. How the facilities worked

Treasury collateral made available through the TSLF was allocated via auction.¹⁵ The day before each auction, the Fed announced the par value of the offering amount, the particular basket of Treasury securities it was willing to lend, and collateral eligible for delivery against the Treasury securities. Schedule 1 collateral consisted of the collateral eligible in the Fed's open market operations; that is, Treasury securities, agency debt securities, and agency MBS. Schedule 2 collateral consisted of Schedule 1 collateral (Fed-eligible collateral) plus other investment-grade debt securities.¹⁶

Auctions were typically held at 2 p.m. Eastern time and were open for 30 minutes. Dealers could submit up to two bids. The minimum bid was \$10 million, each bid could be for no more than 20% of the offering amount, and each

¹⁴ We do not consider borrowing by other broker-dealers under terms similar to that of the PDCF. Fleming (2012) reports PDCF borrowing peaked at \$147 billion, including this other broker-dealer credit.

¹⁵ See Fleming, Hung, and Keane (2009) and Adrian, Burke, and McAndrews (2009) for a fuller description of the TSLF and PDCF.

¹⁶ Schedule 2 collateral originally included Schedule 1 collateral plus AAA/Aaa-rated non-agency residential MBS, commercial MBS, and agency collateralized mortgage obligations. Eligible collateral was expanded to include AAA/Aaa-rated asset-backed securities starting with the May 8, 2008 auction and all investment-grade debt securities starting with the September 17, 2008 auctions.

dealer could be awarded no more than 20% of the offering amount. The auctions were single-priced, so that all accepted dealer bids were awarded at the same rate, which was the lowest rate that filled the auction (also called the stop-out rate). The minimum fees for Schedule 1 and Schedule 2 auctions were 10 and 25 basis points (per annum), respectively.

Shortly after the auction close, the Fed informed dealers of their firm's awards and posted summary auction results to the New York Fed's website. Loans settled on the business day following auction. Treasury collateral was allocated to dealers on a pro rata basis, so that a dealer awarded 10% of the offering amount received a 10% share of each Treasury security offered. The Fed reserved the right to substitute lent general collateral each day so as to avoid providing collateral that could trade with scarcity value in the repo market.

To mitigate credit risk, the Fed imposed a haircut on the collateral pledged by dealers, so that dealers had to pledge collateral with a market value greater than the market value of the Treasury securities being borrowed.¹⁷ Moreover, dealers had to ensure that the market value of their collateral remained sufficient on a daily basis. Dealers could therefore need to make collateral substitutions over the term of a loan if the pledged collateral deteriorated in value or fell out of the eligible collateral pool.

In contrast to the TSLF, the PDCF was a standing facility in which dealers were allocated funds at a set rate against eligible collateral. The rate was set equal to the discount window's primary credit rate, although the Fed also imposed an additional fee on frequent borrowers.¹⁸ Eligible collateral originally was composed of Fed-eligible collateral plus investment-grade corporate securities, municipal securities, MBS, and asset-backed securities (ABS), but it was expanded to include all collateral eligible for tri-party repo, including non-investment-grade securities and equities, after September 14, 2008. As with the TSLF, the Fed imposed a haircut on the pledged collateral to mitigate credit risk.

3. Data

3.1. TSLF and PDCF participation

Our TSLF and PDCF data come from three sources. First, certain aggregate information about program operations was released around the times of the operations.¹⁹ For the TSLF, information announced in advance of an operation included the total quantity of Treasury collateral offered and the type of collateral that could be pledged against the Treasury securities. After the operation, the Fed disclosed the aggregate quantity bid, the quantity awarded, and the stop-out rate (see Appendix Table A1). For the PDCF, the

Fed disclosed the average amount borrowed and borrowing outstanding on a weekly basis.

Second, on December 1, 2010, the Fed released additional information about transactions conducted to stabilize markets during the financial crisis.²⁰ For both the TSLF and PDCF, this includes information on individual dealer borrowings through the facility, such as the name of the borrower and the amount lent (par value and market value in the case of the TSLF). Also released was information on the collateral pledged, including the market value of the collateral pledged, the collateral type, and the collateral rating. The collateral information is provided as of the start date of a new loan and, in the case of the TSLF, is aggregated to reflect all of a dealer's outstanding TSLF loans as of that date.

Third, for the TSLF, we utilize a proprietary data set with somewhat greater information than the data released December 1, 2010. In particular, while the data set released in December 2010 contains quantities borrowed and lending fees (which are based on the stop-out rate), these additional data include the particular fees bid and the associated quantities, regardless of whether the bid was successful or not. Such information is available for each bid in instances in which dealers submitted two bids. As a result, our study goes beyond the analysis in Krishnamurthy, Nagel, and Orlov (2014) by examining ex ante bidding behavior and not just ex post auction realizations in the TSLF.

Summary statistics across TSLF and PDCF borrowing opportunities, reported in Table 2, indicate substantial variation in borrowing behavior over time. In TSLF Schedule 1 operations, for which the offering amount was always \$25 billion, bid-to-cover ratios ranged from 0 to 2.1, the number of bidding dealers ranged from 0 to 14, and the stop-out rate ranged from the minimum fee of 10 basis points at numerous operations to 151 basis points at the post-Lehman bankruptcy (September 18, 2008) operation. In TSLF Schedule 2 operations, for which the offering amount ranged from \$25 billion to \$75 billion, bid-to-cover ratios ranged from 0 to 2.0, the number of bidding dealers ranged from 0 to 16, and the stop-out rate ranged from the minimum fee of 25 basis points at numerous operations to 322 basis points at the October 15, 2008 operation. In the PDCF, with no set borrowing limit, the amount borrowed ranged from \$0 to \$130 billion, and the number of borrowing dealers ranged from 0 to 10.

Summary statistics for individual dealer borrowing from the facilities, reported in Table 3, indicate substantial variation in behavior across dealers. Citigroup borrowed in 63 of the 91 TSLF operations, and from the PDCF on 174 days, with average borrowing (across operations at which it did and did not borrow) of \$2.1 billion at TSLF Schedule 1 operations, \$3.8 billion at TSLF Schedule 2 operations, and \$3.7 billion at the PDCF. At the other extreme, Daiwa Securities never borrowed from the TSLF and borrowed only once from the PDCF.²¹

¹⁷ The Fed did not suffer credit losses in either of these facilities, and the facilities were thus profitable for the Fed and, hence, US taxpayers.

¹⁸ At program inception, the frequency-based fees were assessed on borrowers who accessed the PDCF on more than 30 business days out of 120 business days. The fees were later assessed on borrowers who accessed the facility on more than 45 business days.

¹⁹ This information is available on the New York Fed's website at http://www.newyorkfed.org/markets/tslf/termseclending_Historical.cfm.

²⁰ This information is available on the Fed's website at http://www.federalreserve.gov/newsevents/reform_tsif.htm.

²¹ To the extent possible, our analysis incorporates the 20 firms that were primary dealers at the start of the programs, including the five firms (Bear Stearns, Countrywide, Dresdner Kleinwort, Lehman Brothers, and

Table 2

Operation summary statistics.

The table reports summary statistics for the 33 Term Securities Lending Facility (TSLF) Schedule 1 auctions, 58 TSLF Schedule 2 auctions, and 470 days the Primary Dealer Credit Facility (PDCF) was open. The stop-out rate represents the lowest rate at which bids are accepted. The bid-to-cover ratio represents the ratio of the amount submitted to the amount offered. Operation summary statistics are not conditional on dealers having participated in an operation.

Variable	Mean	Standard deviation	Minimum	Maximum
<i>Panel A: TSLF Schedule 1</i>				
Amount offered (billions of dollars)	25.0	0.0	25.0	25.0
Amount submitted (billions of dollars)	21.2	17.6	0.0	51.7
Amount accepted (billions of dollars)	15.3	10.3	0.0	25.0
Stop-out rate (basis points)	17.1	25.4	10.0	151.0
Bid-to-cover ratio	0.8	0.7	0.0	2.1
Number of bidding dealers	5.9	4.6	0.0	14.0
Number of awarded dealers	4.7	3.3	0.0	12.0
<i>Panel B: TSLF Schedule 2</i>				
Amount offered (billions of dollars)	47.9	16.9	25.0	75.0
Amount submitted (billions of dollars)	28.8	21.5	0.0	86.1
Amount accepted (billions of dollars)	24.8	16.1	0.0	75.0
Stop-out rate (basis points)	48.0	70.7	25.0	322.0
Bid-to-cover ratio	0.7	0.5	0.0	2.0
Number of bidding dealers	7.3	4.5	0.0	16.0
Number of awarded dealers	6.7	4.1	0.0	15.0
<i>Panel C: PDCF</i>				
Amount borrowed (billions of dollars)	15.7	24.7	0.0	129.6
Number of awarded dealers	2.2	2.6	0.0	10.0

Table 3

Dealer borrowing summary statistics.

The table reports the average amount borrowed and the number of borrowings by dealer for the 33 Term Securities Lending Facility (TSLF) Schedule 1 operations, 58 TSLF Schedule 2 operations, and 470 days the Primary Dealer Credit Facility (PDCF) was open. Dealers are ordered in the table based on the total amount borrowed from the various facilities, weighted by borrowing term. Average borrowing amounts are calculated over all operation days even if a dealer was not a primary dealer for some of those days.

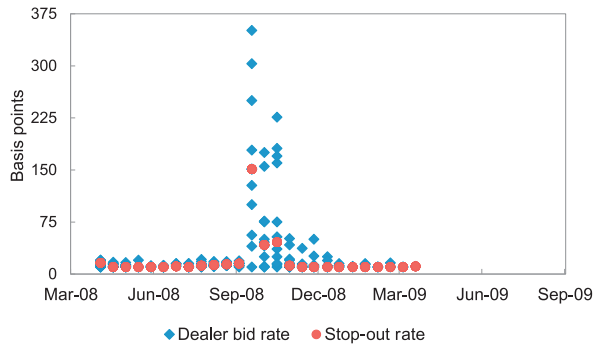
Dealer	TSLF Schedule 1		TSLF Schedule 2		PDCF	
	Average amount borrowed (millions of dollars)	Number of borrowings	Average amount borrowed (millions of dollars)	Number of borrowings	Average amount borrowed (millions of dollars)	Number of borrowings
Citigroup Global Markets Inc.	2,086.0	20	3,780.5	43	3,737.8	174
Deutsche Bank Securities Inc.	2,746.4	20	2,546.4	31	1.1	1
RBS Securities Inc.	1,610.2	14	3,298.3	43	0.0	0
Credit Suisse Securities (USA) LLC	1,591.7	11	2,965.5	41	3.2	2
Goldman, Sachs & Co.	1,221.0	15	2,444.8	36	922.6	52
Barclays Capital Inc.	1,732.9	21	1,700.4	43	873.3	74
Merrill Lynch Government Securities Inc.	609.5	5	2,298.3	33	3,164.1	99
UBS Securities LLC.	437.6	4	1,631.0	17	75.3	8
Morgan Stanley & Co. Incorporated	517.3	6	1,224.1	25	2,903.0	122
Banc of America Securities LLC	837.5	8	819.8	14	1,359.3	118
Lehman Brothers Inc.	394.6	5	1,275.9	13	177.3	10
J.P. Morgan Securities LLC	574.7	7	580.1	14	6.4	3
BNP Paribas Securities Corp.	718.2	9	99.4	10	141.2	43
Countrywide Securities Corporation	96.7	5	59.7	5	163.9	75
Bear, Stearns & Co., Inc.	0.0	0	34.5	2	2,042.8	69
Cantor Fitzgerald & Co.	60.6	4	10.3	5	59.7	61
HSBC Securities (USA) Inc.	0.0	0	51.7	11	0.0	0
Dresdner Kleinwort Securities LLC	32.5	2	0.0	0	0.2	1
Mizuho Securities USA Inc.	0.0	0	0.0	0	90.0	108
Daiwa Securities America Inc.	0.0	0	0.0	0	0.9	1

While Table 3 indicates high variation in borrowing behavior across dealers, it also demonstrates a certain

Merrill Lynch) that were no longer primary dealers at the end of the programs. Our analysis excludes the three firms that became primary dealers while the facilities were operating (Jefferies, RBC, and Nomura), because all three firms became primary dealers in June or July 2009 when use of the facilities was winding down as market conditions improved (and none of the three firms ever borrowed via the facilities).

consistency in behavior across facility types for a given dealer. That is, dealers who borrowed heavily from one facility tended to borrow heavily from another. The correlation coefficients across dealers for average amount borrowed are thus 83% between TSLF Schedules 1 and 2, 17% between TSLF Schedule 1 and the PDCF, and 37% between TSLF Schedule 2 and the PDCF. The most striking inconsistency in borrowing behavior across facility types is that dealers with European parents were often heavy

Panel A: Dealer bid rates in TSLF Schedule 1 auctions



Panel B: Dealer bid rates in TSLF Schedule 2 auctions

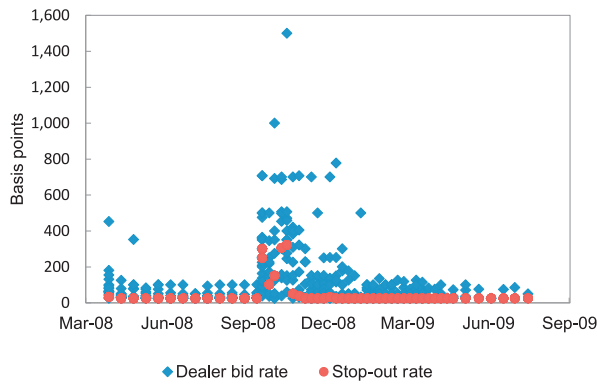


Fig. 4. Dealer bid rates in Term Securities Lending Facility (TSLF) auctions. The figure plots dealer bid rates in TSLF Schedule 1 (Panel A) and Schedule 2 (Panel B) auctions. Each diamond represents a dealer's average bid rate, weighted by bid amount. Each circle represents an auction's stop-out rate. The last Schedule 1 (Schedule 2) auction was held June 25, 2009 (January 7, 2010), but no bids were made after the March 19, 2009 (July 16, 2009) auction.

borrowers from the TSLF, but very light borrowers from the PDCF. RBS, for example, borrowed from the TSLF on 57 occasions, but never borrowed from the PDCF.

Not only was there variation across dealers and facilities in borrowing amounts, but evidence also exists of substantial variation in dealer behavior for a given operation as shown in Fig. 4. The figure plots dealer bid rates for every dealer-auction pair for both TSLF Schedule 1 (Panel A) and Schedule 2 (Panel B) operations. For instances in which a dealer submitted two bids, we plot the average bid, weighted by bid amounts.²² The figure illustrates tremendous variation in dealer bid rates, especially after the failure of Lehman. For example, at the September 18, 2008 Schedule 1 auction, ten dealers submitted bids, ranging from 10 to 351 basis points, and at the October 15, 2008 Schedule 2 operation, 11 dealers submitted bids, ranging from 60 to 1,500 basis points.

²² In Schedule 1 operations, dealers submitted one bid on 125 occasions and two bids on 69 occasions. In Schedule 2 operations, dealers submitted one bid on 253 occasions and two bids on 168 occasions.

3.2. Repo rates

Our source for repo rate data is the New York Fed's primary dealer survey. Each morning, before its typical open market operation time of 9:30, the trading desk at the New York Fed collects information from primary dealers on general collateral repo rates for Treasury securities, agency debt securities, and agency MBS. These data are used to help gauge funding market conditions and to set spreads for the Fed's open market operations. We primarily use data on one-month repo rates, which are averaged from indicative rates provided by a subset of primary dealers.

3.3. Dealer conditions

We collect data from Bloomberg on two measures of dealer balance sheet conditions during the crisis: cumulative equity return and leverage. Cumulative equity return measures the equity performance (return) of a firm from January 2, 2007. Leverage is measured by the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of non-equity liabilities) to market value of equity, in which the book value of non-equity liabilities is measured as the book value of assets minus the book value of equity. While book data are available on a quarterly frequency, the market value of equity is updated on a daily basis. It follows that the quasi-leverage measure changes on a daily basis within a quarter due to market equity fluctuations and across quarters also due to updated information on the book value of non-equity liabilities. While in tables and figures we refer to the measure as quasi-leverage, in the text we simply call it leverage for parsimony of expression.²³

Summary statistics for the equity return and leverage variables are reported in Table 4. Given that the TSLF and PDCF were introduced and operated during the financial crisis, it is not surprising to see a mean cumulative equity return of -51% since January 2, 2007, with a worst performance of -99.9% and a best performance of 4.9% . The mean leverage ratio is 42 and varies from a low of 5 to a high of more than 680. The high maximum leverage ratio is not surprising because the market value of equity approaches zero for a bankrupt firm. The other statistics indicate substantial variation in leverage and returns in both the cross section and the time series, as the last two columns illustrate. That is, substantial variation exists in equity returns and leverage across dealers at given times, as well as over time for given dealers. The cross-sectional variation is the key variation we exploit in our empirical analysis, as we control for time series variation through time fixed effects.

²³ The primary dealers that participated in the facilities are often subsidiaries of larger financial firms. Leverage and equity performance are measured for the holding company in such instances. In some instances, leverage and equity returns are not available at all. Cantor Fitzgerald, in particular, is not publicly traded and is thus excluded from the regression analyses.

Table 4

Dealer financial condition summary statistics.

The table reports summary statistics of dealer financial conditions for March 16, 2008 through January 29, 2010. Cumulative equity returns are measured from January 2, 2007. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity. MMF non-Fed eligible collateral is the share of collateral pledged to money market funds between December 1, 2007 and February 29, 2008 that was not US Treasury, agency debt, or agency mortgage-backed securities. The average standard deviation of the cross section equals the average of the standard deviations calculated across dealers for each auction. The average standard deviation of the time series equals the average of the standard deviations calculated across auctions for each dealer.

Variable	Mean	Standard deviation	Minimum	Maximum	Average standard deviation of the cross section	Average standard deviation of the time series
Equity return (percent)	-50.8	26.0	-99.9	4.9	23.1	14.7
Quasi-leverage	42.2	50.6	4.7	682.5	38.8	28.1
MMF non-Fed eligible collateral (percent)	19.5	17.2	0.0	61.3	–	–

3.4. Money market fund collateral

Our money market fund (MMF) collateral data come from the Securities and Exchange Commission website and is based on quarterly filings of 40 large money market funds. Each observation in the raw MMF data set pertains to one repo between a specific fund and a specific counterparty and includes details such as purchase date, maturity date, collateral class, face value, maturity amount, and collateral value. The nine collateral classes are Treasuries, agencies, corporate debt, commercial paper, municipals, foreign debt, equities, structured finance, and mixed pool. The information is thus detailed enough to allow us to distinguish collateral that is Fed-eligible from that which is not. Table 4 reports summary statistics across dealers for the share of pledged collateral that was non-Fed-eligible over the December 1, 2007 to February 29, 2008 period, showing that the share ranged from 0% to 61% and averaged just under 20%.²⁴

4. Results

We explain dealer behavior in each of the facilities with our measures of dealer financial conditions. Let y_{it} be a measure of behavior of dealer i on TSLF auction date t or PDCF borrowing date t , and let x_{it-1} be a measure of dealer i 's financial condition as of the day preceding the facility operation date. Our basic regression specification is then

$$y_{it} = \alpha_0 + \gamma_t + \beta x_{it-1} + \varepsilon_{it}, \quad (1)$$

in which γ_t represents a time fixed effect to control for any pure time series variation that affects y_{it} . Dealer behavior is estimated separately for the TSLF Schedules 1 and 2 and PDCF because of the different designs of the facilities or differing collateral that could be pledged, or both.

As proxies for dealer behavior y_{it} , we use the dealer's bidding or borrowing (i.e., participation) decision, the bid or borrowing amount, and the TSLF bid rate. Our proxy for financial conditions is the dealer's cumulative equity return from January 2, 2007 or the dealer's leverage.²⁵ Because of

the high correlation between the two variables, we generally estimate Eq. (1) using equity return or leverage separately. However, for completeness, we also estimate a version of Eq. (1) with both return and leverage:

$$y_{it} = \alpha_0 + \gamma_t + \beta_1 \text{Equity return}_{it-1} + \beta_2 (10/\text{Leverage}_{it-1}) + \varepsilon_{it}. \quad (2)$$

4.1. Participation

We first relate a dealer's decision to participate in a facility to its financial condition. Participation is defined by an indicator variable equal to one if a dealer submitted a bid in a TSLF auction or borrowed at the PDCF and zero otherwise. Results from least squares regressions, reported in Table 5, support the hypothesis that firms with weaker financial conditions were more likely to participate.²⁶ Equity return is negative and statistically significant in the TSLF Schedule 1 and Schedule 2 operations (Columns 1 and 4) and the PDCF (Column 7). The reciprocal of leverage is negative and statistically significant in both Schedule 1 and Schedule 2 operations (Columns 2 and 5) and negative and statistically insignificant in the PDCF (Column 8). Individual coefficients are generally weaker when we include both equity return and leverage in the regressions, but the coefficients are jointly significant at the 10% level or better for all facilities.²⁷

The effect of dealer financial conditions on participation is not only statistically significant but also economically significant. Using the coefficients in Columns 1, 4, and 7 of Table 5, we find that a one standard deviation negative shock to cumulative equity return (i.e., -26%) increases a dealer's likelihood of participation in TSLF Schedule 1 operations (in which the average participation rate is 34%) by 12 percentage points (pp), in TSLF Schedule 2 operations (in which the average participation rate is 43%) by 20 pp, and in the PDCF (in which the average participation rate is

leverage has a long right tail. To the extent that lower equity returns or higher leverage impact LOLR utilization in the same manner, the coefficients for equity returns and 10/leverage are of the same sign.

²⁶ We report results using least squares because the coefficients are easier to interpret. Results in Appendix Table A2 show that the results are, if anything, somewhat stronger if we instead use probit estimation, which accounts for the binary nature of the dependent variable.

²⁷ In the case of the PDCF, both variables are significant (Column 9), but the leverage coefficient has the incorrect sign.

²⁴ We have no collateral data over this period for five of the 20 firms that were primary dealers in March 2008: Cantor Fitzgerald, Countrywide, Dresdner Kleinwort, Daiwa, and RBS.

²⁵ In our specifications, we use the reciprocal of leverage (multiplied by ten for presenting the results) as our independent variable given that

Table 5

Explaining whether a dealer participates.

The table reports the results of ordinary least squares participation regressions for the Term Securities Lending Facility (TSLF) and Primary Dealer Credit Facility (PDCF). The TSLF Schedule 1 (Schedule 2) dependent variable is an indicator variable equal to one if a dealer submitted a bid in a Schedule 1 (Schedule 2) auction and zero otherwise. The PDCF dependent variable is an indicator variable equal to one if a dealer borrowed from the PDCF on a given day and zero otherwise. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each operation. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% level, respectively. Equity return and quasi-leverage coefficients marked ⁱⁱⁱ, ⁱⁱ, and ^j are jointly significant at the 1%, 5% and 10% level, respectively.

Independent variable	TSLF Schedule 1			TSLF Schedule 2			PDCF		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Equity return	−0.447* (0.218)		−0.205 ^j (0.278)	−0.774*** (0.223)		−0.640** ⁱⁱⁱ (0.244)	−0.271* (0.152)		−0.348** ^{ij} (0.147)
10/Quasi-leverage		−0.427** (0.168)	−0.314 ^j (0.223)		−0.533*** (0.173)	−0.180 ⁱⁱⁱ (0.165)		−0.064 (0.098)	0.106 ^{ij} (0.056)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.597*** (0.145)	0.938*** (0.127)	0.824*** (0.219)	0.587*** (0.138)	1.110*** (0.086)	0.723*** (0.155)	0.113 (0.095)	(0.127)	0.033 (0.097)
Number of observations	534	533	533	912	911	911	7,286	7,277	7,277
Adjusted r-squared	0.300	0.308	0.311	0.314	0.275	0.317	0.193	0.159	0.198

12%) by 7 pp. The analogous increases in participation for a one standard deviation negative shock to the reciprocal of leverage are 12 pp, 15 pp, and 2 pp, respectively.

The baseline specifications we present fully control for aggregate variation in funding market conditions through time fixed effects. However, to better understand the factors driving aggregate participation over time, we also test specifications in which we drop the time fixed effects but include the one-month agency MBS repo spread (defined as the one-month agency MBS repo rate minus the one-month Treasury repo rate) and the cross-sectional mean values of dealer financial conditions (measured across all dealers and not just the participating ones) as of the day preceding a given operation:

$$y_{it} = \alpha_0 + \alpha_1 \text{Repo spread}_t + \beta_1 \text{Equity return}_{it-1} + \beta_2 \overline{\text{Equity return}}_{t-1} + \varepsilon_{it} \quad (3)$$

and

$$y_{it} = \alpha_0 + \alpha_1 \text{Repo spread}_t + \beta_1 (10/\text{Leverage}_{it-1}) + \beta_2 (10/\overline{\text{Leverage}}_{t-1}) + \varepsilon_{it}. \quad (4)$$

As shown in Table 6, the mean equity return coefficient is positive and statistically significant for both schedules of the TSLF and insignificantly negative for the PDCF. The mean leverage coefficient is positive for both schedules of the TSLF and negative for the PDCF, but only statistically significant for TSLF Schedule 1. We interpret the results as evidence of strategic interaction in the case of the TSLF, in which the quantity of Treasury collateral offered is limited, so that as the financial conditions of their competitors deteriorates, dealers anticipate that competitors will bid more aggressively for liquidity and thus become less likely to participate themselves. That is, stronger dealers are crowded out.²⁸ Such crowding out is not present

in the PDCF in which lendable amounts are not fixed. Table 6 also shows that the repo spread is positively and significantly related to participation in every specification, indicating that dealers are more likely to participate when their opportunity cost of funding in the private market is higher.

4.2. Bid or borrowing amount

We proceed to examine how the quantity bid or borrowed by a dealer varies with its financial condition. We standardize TSLF bidding amounts by defining the quantity bid as the amount of a dealer's bid (across both bids if it submitted two) divided by the maximum possible auction award. Technically, each of a dealer's two bids could be as large as the maximum auction award, so that the ratio could conceivably be as large as two.²⁹ Empirically, the ratio rarely exceeded one. We cap the ratio at one, so that our dependent variable ranges between zero and one. The PDCF did not have explicit borrowing limits. PDCF borrowing amounts are in the tens of billions of dollars.

We again test three model specifications for each of the operation types. These specifications are conditional on a dealer bidding in a TSLF auction or borrowing at the PDCF, which effectively drops all observations for which the dependent variable equals zero. While the earlier results showed that dealer participation was related to its financial condition, the results conditional on participation address whether financial conditions can further explain the quantity borrowed or bid if a bid is submitted.

lack of participation of stronger firms does not mean that such firms did not benefit from the facility if participation of weaker firms eased funding conditions and reduced the chances of fire sales more generally. Also the TSLF imposed a 20% award limit at each auction, ensuring that liquidity could be supplied to at least five dealers.

²⁹ If an auction were oversubscribed, then awards would be rationed at the stop-out rate. It follows that a dealer submitting two bids could want to increase the size of its less competitive bid to increase its award should the auction stop at the lower rate.

²⁸ Put another way, stronger dealers seem to have better financing opportunities elsewhere (i.e., in the private market) and thus choose to participate less in the TSLF given the presence of weaker dealers that have fewer or more expensive financing opportunities elsewhere. The relative

Table 6

Explaining whether a dealer participates (without time fixed effects).

The table reports the results of ordinary least squares participation regressions for the Term Securities Lending Facility (TSLF) and Primary Dealer Credit Facility (PDCF). The TSLF Schedule 1 (Schedule 2) dependent variable is an indicator variable equal to one if a dealer submitted a bid in a Schedule 1 (Schedule 2) auction and zero otherwise. The PDCF dependent variable is an indicator variable equal to one if a dealer borrowed from the PDCF on a given day and zero otherwise. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each operation. Mean cumulative equity return and mean quasi-leverage are auction-level averages across all dealers. The repo spread is the difference between the one month repo rate for agency mortgage-backed securities collateral and the one month repo rate for Treasury general collateral and is measured as of the morning preceding each operation. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% levels, respectively.

Independent variable	TSLF Schedule 1		TSLF Schedule 2		PDCF	
	(1)	(2)	(3)	(4)	(5)	(6)
Equity return	-0.453** (0.203)		-0.761*** (0.200)		-0.266* (0.148)	
Mean equity return	1.475*** (0.220)		1.170*** (0.243)		-0.160 (0.324)	
10/Quasi-leverage		-0.427** (0.164)		-0.533*** (0.160)		-0.006 (0.010)
Mean 10/quasi-leverage		1.581*** (0.230)		0.290 (0.284)		-0.050 (0.033)
One month repo spread (percent)	0.517*** (0.096)	0.547*** (0.101)	0.492*** (0.072)	0.516*** (0.079)	0.432*** (0.098)	0.375*** (0.085)
Time fixed effects	No	No	No	No	No	No
Constant	0.760*** (0.102)	-0.243** (0.087)	0.541*** (0.094)	0.400** (0.158)	-0.184 (0.142)	0.289* (0.155)
Number of observations	534	533	912	911	7,286	7,277
Adjusted r-squared	0.233	0.202	0.217	0.177	0.185	0.158

Table 7

Explaining bid or borrowing amounts, conditional on participation.

The table reports the results of ordinary least squares bid or borrowing amount regressions for the Term Securities Lending Facility (TSLF) and Primary Dealer Credit Facility (PDCF). The TSLF Schedule 1 (Schedule 2) dependent variable is the ratio of the total amount a dealer bid in a given Schedule 1 (Schedule 2) auction to the maximum award amount. The PDCF dependent variable is the amount borrowed from the PDCF on a given day, in tens of billions of dollars. The dependent variables are conditional on participation and hence undefined when a dealer does not bid (TSLF) or borrow (PDCF). Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each operation. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% level, respectively. Equity return and quasi-leverage coefficients marked ⁱⁱⁱ, ⁱⁱ, and ⁱ are jointly significant at the 1%, 5% and 10% level, respectively.

Independent variable	TSLF Schedule 1			TSLF Schedule 2			PDCF		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Equity return	-0.147 (0.257)		-0.126 (0.318)	-0.459** (0.171)		-0.520 ⁱⁱ (0.257)	-1.936** (0.773)		-1.336 ⁱⁱ (0.753)
10/Quasi-leverage		-0.094 (0.260)	-0.036 (0.320)		-0.222 (0.173)	0.100 ⁱⁱ (0.244)		-1.984** (0.696)	-1.047 ⁱⁱ (0.561)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.662*** (0.099)	0.747*** (0.164)	0.684** (0.233)	0.478*** (0.122)	0.218* (0.104)	0.152 (0.218)	-1.086** (0.438)		-0.390 (0.478)
Number of observations	189	188	188	409	408	408	861	860	860
Adjusted r-squared	0.003	-0.006	-0.006	0.282	0.343	0.343	0.273	0.225	0.311

Results of our least squares regressions, reported in Table 7, provide evidence that firms with weaker financial conditions tended to bid or borrow larger quantities.³⁰ The equity return variable is negative and statistically significant for both TSLF Schedule 2 operations and PDCF borrowings (Columns 4 and 7) and negative but insignificant for TSLF Schedule 1 operations (Column 1). The reciprocal

of the leverage variable is negative and statistically significant for PDCF borrowings (Column 8) but negative and insignificant for the TSLF operations (Columns 2 and 5). The results are robust to including equity return and leverage together in the specifications (Columns 3, 6, and 9).

As with participation, the effect of dealer financial conditions is not only statistically significant but also economically significant. Using the coefficients in Columns 4 and 7 of Table 7, we find that a one standard deviation negative shock to the cumulative equity return increases a dealer's borrowing ratio in the Schedule 2 TSLF (in which the average ratio conditional on participation is 46%) by 12 pp, and

³⁰ Results in Appendix Table A3 show that the results are, if anything, somewhat stronger if we instead use Tobit estimation for the TSLF specifications to account for the fact that the dependent variables are censored at one.

Table 8

Explaining bid rates.

The table reports results of ordinary least squares bid rate regressions for the Term Securities Lending Facility (TSLF). The dependent variable is the bid rate. If a dealer submitted two bids in an auction, then the dependent variable equals the average bid rate weighted by bid amount. The dependent variable is undefined if a dealer did not submit any bids. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each auction. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each auction. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% level, respectively. Equity return and quasi-leverage coefficients marked ⁱⁱⁱ, ⁱⁱ, and ^j are jointly significant at the 1%, 5% and 10% level, respectively.

Independent variable	TSLF Schedule 1			TSLF Schedule 2		
	(1)	(2)	(3)	(4)	(5)	(6)
Equity return	-0.134 (0.144)		0.039 ^{ij} (0.177)	-2.210* (1.076)		-2.294 ^{ij} (1.772)
10/Quasi-leverage		-0.389** (0.137)	-0.408** ^{ij} (0.169)		-1.324* (0.633)	0.095 ^{ij} (1.360)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.103** (0.039)	0.312*** (0.066)	0.331*** (0.111)	0.271 (0.422)	1.639*** (0.458)	0.199 (1.194)
Number of observations	189	188	188	409	408	408
Adjusted r-squared	0.480	0.502	0.499	0.367	0.319	0.365

PDCF borrowing amounts (in which the average borrowing amount conditional on borrowing is \$7 billion) by \$5 billion. The analogous increases in borrowing for a one standard deviation negative shock to the reciprocal of leverage are 6 pp and \$6 billion, respectively.

4.3. Bid rate

Our third measure of liquidity demand is a dealer's bid rate. This variable is defined as the average bid rate, weighted by bid amount for instances in which a dealer submitted two bids. Bid rates are naturally not observed for dealers that did not submit bids, so the sample is necessarily conditional on a dealer having submitted a bid. The bid rate analysis is pertinent to the TSLF only because the PDCF was a standing facility with a fixed borrowing rate for a given day.

The results of our least squares regressions, reported in Table 8, are supportive of the hypothesis that firms with weaker financial conditions bid higher rates.³¹ Equity return is negative and statistically significant for Schedule 2 operations (Column 4) and negative but insignificant for Schedule 1 operations (Column 1). The reciprocal leverage variable is negative and statistically significant for both schedules (Columns 2 and 5). Some individual coefficients become insignificant when both return and leverage are included together (Columns 3 and 6), but the two variables are jointly significant at the 5% level for both schedule types.

As with participation and bid amounts, the effects of dealer financial conditions are not only statistically significant but also economically significant. Using the coefficients in Columns 1 and 4 of Table 8, we find that a one standard deviation negative shock to the cumulative equity

return increases a dealer's bid rate in Schedule 1 auctions (in which the average bid rate is 29 basis points) by 3 basis points and in Schedule 2 auctions (in which the average bid rate is 94 basis points) by 57 basis points. The analogous increases in bid rates for a one standard deviation negative shock to the reciprocal of leverage are 11 and 38 basis points, respectively.

5. Additional analyses

While both the TSLF and PDCF offered secured loans to primary dealers, important differences exist in the design of these facilities (see Table 1). The TSLF offered 28-day term loans at periodically scheduled auctions, and the PDCF offered overnight loans on an as needed basis. The TSLF allocated collateral via auction at an auction-determined rate, whereas the PDCF lent funds on a standing basis at a predetermined rate. Moreover, a broader range of eligible collateral was accepted in the PDCF (e.g., equity and whole loans after September 14, 2008) than in the TSLF. In this section, we exploit these cross-sectional differences in program terms to better understand dealer behavior in the facilities.

5.1. Collateral effects

One of the most important distinctions among the facilities was the varying types of assets that could be pledged as collateral. The ability of firms to pledge a wider range of collateral at the PDCF than in the TSLF, and in TSLF Schedule 2 operations versus Schedule 1 operations, could have provided an incentive for some firms to prefer borrowing at one facility over another. In particular, the ability to pledge corporate and municipal bonds at the PDCF in the pre-Lehman period and equity and whole loans in the post-Lehman period could have been valuable to firms with large amounts of these securities on their balance sheets.

³¹ Results in Appendix Table A4 show that the results are somewhat stronger if we instead use Tobit estimation for the specifications to account for the fact that the dependent variables are censored at the minimum bid rates (of 10 and 25 basis points, respectively, for Schedule 1 and Schedule 2 operations).

Table 9

Summary statistics of collateral pledged against borrowings.

The table reports the proportions of collateral pledged against Term Securities Lending Facility (TSLF) Schedule 2 borrowings and Primary Dealer Credit Facility (PDCF) borrowings, grouped by the ratings assigned to the collateral and by collateral type. The rating is based on a composite credit rating of the pledged collateral, based on ratings information used by the borrower's clearing bank. Dealers are ordered in the same manner as Table 3. MBS=mortgage-backed security; CMO=collateralized mortgage obligation; NA=not applicable.

Panel A: TSLF Schedule 2 distribution by collateral rating

Dealer	Aaa/AAA	Aa/AA	A	Baa/BBB	Commercial paper
Citigroup Global Markets Inc.	88.5	5.0	3.7	2.4	0.4
Deutsche Bank Securities Inc.	73.5	4.6	8.2	8.4	5.3
RBS Securities Inc.	75.4	4.3	3.6	3.6	13.1
Credit Suisse Securities (USA) LLC	54.7	4.6	14.3	20.8	5.5
Goldman, Sachs & Co.	88.3	5.3	3.1	3.3	0.0
Barclays Capital Inc.	52.7	9.7	15.9	21.7	0.0
Merrill Lynch Government Securities Inc.	80.4	7.5	3.4	7.4	1.3
UBS Securities LLC.	84.9	3.2	6.0	5.9	0.0
Morgan Stanley & Co. Incorporated	51.0	11.3	5.3	2.9	29.5
Banc of America Securities LLC	90.9	5.0	2.3	1.7	0.0
Lehman Brothers Inc.	100.0	0.0	0.0	0.0	0.0
J.P. Morgan Securities LLC	80.2	1.7	1.8	2.2	14.2
BNP Paribas Securities Corp.	93.2	0.4	4.2	2.2	0.0
Countrywide Securities Corporation	100.0	0.0	0.0	0.0	0.0
Bear, Stearns & Co., Inc.	100.0	0.0	0.0	0.0	0.0
Cantor Fitzgerald & Co.	100.0	0.0	0.0	0.0	0.0
HSBC Securities (USA) Inc.	60.7	13.9	17.7	7.2	0.5
Dresdner Kleinwort Securities LLC	NA	NA	NA	NA	NA
Mizuho Securities USA Inc.	NA	NA	NA	NA	NA
Daiwa Securities America Inc.	NA	NA	NA	NA	NA

Panel B: TSLF Schedule 2 distribution by collateral type

Dealer	Treasury and agency debt	MBS-CMO:					
		agency backed	MBS-CMO: other	Asset-backed	Corporate	Municipal	Other
Citigroup Global Markets Inc.	2.0	63.0	17.9	3.3	1.4	12.4	0.1
Deutsche Bank Securities Inc.	0.0	8.2	54.1	17.4	20.3	0.0	0.0
RBS Securities Inc.	0.1	46.9	22.4	13.2	17.4	0.0	0.0
Credit Suisse Securities (USA) LLC	0.3	28.5	20.9	10.5	39.6	0.2	0.0
Goldman, Sachs & Co.	0.0	68.4	16.1	4.9	4.7	6.0	0.0
Barclays Capital Inc.	0.2	8.4	18.6	29.9	41.3	1.5	0.0
Merrill Lynch Government Securities Inc.	0.3	49.4	19.4	16.3	6.6	8.0	0.0
UBS Securities LLC.	2.1	18.8	60.6	9.2	8.7	0.4	0.0
Morgan Stanley & Co. Incorporated	0.6	15.7	25.7	12.8	37.4	7.7	0.0
Banc of America Securities LLC	0.0	16.9	71.9	6.5	0.6	4.1	0.0
Lehman Brothers Inc.	0.0	58.3	35.0	6.6	0.0	0.0	0.0
J.P. Morgan Securities LLC	0.0	13.8	69.6	1.6	15.0	0.0	0.0
BNP Paribas Securities Corp.	11.6	17.6	70.8	0.0	0.0	0.0	0.0
Countrywide Securities Corporation	4.3	58.4	35.6	1.7	0.0	0.0	0.0
Bear, Stearns & Co., Inc.	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Cantor Fitzgerald & Co.	0.0	100.0	0.0	0.0	0.0	0.0	0.0
HSBC Securities (USA) Inc.	7.0	0.3	15.5	33.1	15.6	26.1	2.4
Dresdner Kleinwort Securities LLC	NA	NA	NA	NA	NA	NA	NA
Mizuho Securities USA Inc.	NA	NA	NA	NA	NA	NA	NA
Daiwa Securities America Inc.	NA	NA	NA	NA	NA	NA	NA

Panel C: PDCF distribution by collateral rating

Dealer	Aaa/AAA	Aa/AA	A	Baa/BBB	Ba/BB	B	Caa/CCC or Ratings			Commercial paper	
							lower	unavailable	Equity		
Citigroup Global Markets Inc.	27.4	10.3	6.8	7.6	5.4	7.8	8.3	12.1	12.6	0.0	1.7
Deutsche Bank Securities Inc.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
RBS Securities Inc.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Credit Suisse Securities (USA) LLC	0.0	0.0	4.5	0.0	0.6	11.8	14.0	9.8	59.3	0.0	0.0
Goldman, Sachs & Co.	15.1	2.6	2.7	6.2	7.6	9.4	11.0	6.4	38.5	0.0	0.5
Barclays Capital Inc.	26.0	3.5	8.1	27.1	1.1	1.3	1.5	2.3	29.2	0.0	0.0
Merrill Lynch Government Securities Inc.	21.9	3.6	4.5	3.7	1.9	3.1	5.1	15.8	37.9	2.7	0.0
UBS Securities LLC.	10.2	8.5	10.8	35.0	4.8	7.5	6.1	14.7	0.0	0.0	2.5
Morgan Stanley & Co. Incorporated	18.7	7.4	7.7	4.8	3.1	2.6	4.2	17.5	27.2	5.4	1.4
Banc of America Securities LLC	24.6	3.7	3.7	2.8	5.5	6.4	15.5	24.7	13.0	0.0	0.1

(continued on next page)

Table 9 (continued)

Panel C: PDCF distribution by collateral rating												
Dealer	Aaa/AAA	Aa/AA	A	Baa/BBB	Ba/BB	B	Caa/CCC or lower	Ratings unavailable	Equity	Loans	Commercial paper	
Lehman Brothers Inc.	23.6	7.1	14.5	10.6	3.9	3.8	2.7	9.9	9.4	0.0	14.5	
J.P. Morgan Securities LLC	9.4	1.7	0.0	0.3	0.1	31.6	0.7	55.8	0.6	0.0	0.0	
BNP Paribas Securities Corp.	33.3	5.3	8.3	5.8	7.6	11.0	8.1	19.7	0.1	0.0	0.8	
Countrywide Securities Corporation	94.7	1.2	2.8	0.7	0.0	0.0	0.0	0.6	0.0	0.0	0.0	
Bear, Stearns & Co., Inc.	89.8	4.5	2.8	2.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	
Cantor Fitzgerald & Co.	89.1	3.9	6.3	0.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	
HSBC Securities (USA) Inc.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Dresdner Kleinwort Securities LLC	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Mizuho Securities USA Inc.	3.6	15.7	59.6	15.2	1.4	0.0	0.0	3.8	0.0	0.0	0.7	
Daiwa Securities America Inc.	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Panel D: PDCF distribution by collateral type												
Dealer	Treasury and agency debt	MBS-CMO:		MBS-CMO: other	Asset-backed	Corporate	Municipal	Equity	Loans	International	Other	
		agency backed	other									
Citigroup Global Markets Inc.	3.3	0.0	8.1	8.9	25.7	28.2	12.6	0.0	0.0	0.0	13.1	
Deutsche Bank Securities Inc.	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	
RBS Securities Inc.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Credit Suisse Securities (USA) LLC	0.0	0.0	5.1	29.5	6.1	0.0	59.3	0.0	0.0	0.0	0.0	
Goldman, Sachs & Co.	0.0	7.4	14.1	12.9	23.9	1.9	38.5	0.0	0.0	0.0	1.4	
Barclays Capital Inc.	1.8	9.6	6.6	11.4	40.6	0.5	29.2	0.0	0.0	0.0	0.4	
Merrill Lynch Government Securities Inc.	0.3	0.2	2.6	6.1	12.1	13.5	37.9	2.7	0.0	0.0	24.7	
UBS Securities LLC	2.3	3.1	12.2	38.8	40.3	3.3	0.0	0.0	0.0	0.0	0.0	
Morgan Stanley & Co. Incorporated	1.0	0.9	3.6	6.6	18.8	32.6	27.2	5.4	0.2	3.8		
Banc of America Securities LLC	0.8	0.0	11.0	9.8	26.6	18.2	13.0	0.0	0.0	20.6		
Lehman Brothers Inc.	10.2	5.7	4.8	20.6	40.8	6.0	9.4	0.0	0.0	2.5		
J.P. Morgan Securities LLC	0.0	0.0	11.3	44.2	43.9	0.0	0.6	0.0	0.0	0.0		
BNP Paribas Securities Corp.	9.2	10.1	0.5	0.8	58.5	20.8	0.1	0.0	0.0	0.0		
Countrywide Securities Corporation	12.4	18.4	61.6	7.7	0.0	0.0	0.0	0.0	0.0	0.0		
Bear, Stearns & Co., Inc.	0.0	54.5	32.1	13.1	0.4	0.0	0.0	0.0	0.0	0.0		
Cantor Fitzgerald & Co.	0.7	9.4	0.4	89.4	0.1	0.0	0.0	0.0	0.0	0.0		
HSBC Securities (USA) Inc.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Dresdner Kleinwort Securities LLC	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0		
Mizuho Securities USA Inc.	0.1	0.1	0.0	1.7	97.1	0.0	0.0	0.0	0.0	1.0	0.0	
Daiwa Securities America Inc.	99.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table 9 shows the average proportion of collateral pledged by asset type in the TSLF (Schedule 2) and PDCF.³² Panels A and B show that the quality and type of collateral posted at TSLF Schedule 2 operations varied considerably across dealers. Panel A shows that some dealers posted collateral only with a composite rating of Aaa/AAA, whereas only about half of the pledged collateral of other dealers (for example, Barclays Capital and Morgan Stanley) was rated Aaa/AAA.³³ Panel B of Table 9 shows that heavy borrower Citigroup posted a relatively high share (63%)

of agency-backed mortgage securities as collateral. Other heavy program borrowers, such as Deutsche Bank, posted relatively less agency-backed mortgage securities as collateral (8%), but more non-agency backed mortgage securities (54%) and other securities. Barclays posted high shares of both ABS (30%) and corporate securities (41%).

Looking at the PDCF, eight dealers pledged substantial proportions of equity, ranging between 9% for Lehman Brothers and almost 60% for Credit Suisse (see Panel C of Table 9).³⁴ Firms that pledged greater shares of equity tended to be heavy borrowers at the PDCF. Indeed, the correlation between average amount borrowed at the PDCF and the proportion of equity pledged as collateral is 0.39, suggesting that the ability to pledge equity was a strong motive for dealers to borrow at the PDCF. Moreover, dealers that pledged large proportions of equity at the PDCF also pledged large proportions of other risky assets such as MBS and collateralized mortgage obligations, ABS,

³² Collateral information provided by the Fed includes the market value of collateral as of the start of any borrowing and mixes the TSLF Schedule 1 and Schedule 2 collateral together. We infer the collateral pledged against a particular Schedule 2 borrowing by backing out the higher quality collateral pledged against Schedule 1 borrowings as well as the borrowings for any earlier but outstanding Schedule 2 borrowings. Collateral could be changed over the term of a loan, so our TSLF numbers should be considered estimates of collateral pledged at the start of a borrowing. In contrast, the PDCF numbers are not estimates because such data are provided separately from TSLF data and because the daily frequency of PDCF borrowings matched the daily borrowing term.

³³ Until the September 17, 2008 operation, Schedule 2 borrowings were against only Aaa/AAA collateral. It follows that any dealer who borrowed before that time must have pledged only Aaa/AAA collateral over the pe-

riod and that any dealer that did not borrow after the collateral schedule was broadened must have never pledged lower quality collateral.

³⁴ Eligible collateral was expanded to include equities after September 14, 2008. It follows that any dealer who borrowed before that time did not pledge equities over the period.

corporate securities, and municipal securities at both the PDCF and TSLF (see Panels B and D of Table 9) and borrowed extensively at TSLF Schedule 2 operations. Consistent with this notion, the correlation between the average amount borrowed at TSLF Schedule 2 and the proportion of equity pledged as collateral at the PDCF is 0.36. The distribution of collateral pledged at the facilities reinforces the notion that firms with risky assets on their balance sheets had a greater need for funds during the crisis and pledged these assets to borrow substantively at both facilities.

We proceed to formally test the idea that the proportion of illiquid collateral on dealers' balance sheets was a determinant of dealers' demand for liquidity at the PDCF and TSLF Schedule 2 operations (we omit TSLF Schedule 1 auctions because only liquid Fed-eligible collateral was accepted in that program). We do this by relating dealers' bidding or borrowing decision to the quantity of non-Fed-eligible collateral pledged by dealers. The hypothesis is that dealers with greater shares of less liquid collateral would tend to bid for larger quantities of funds at the facilities.

Let $Non\text{-}Fed\text{-}eligible_{i,pre\text{-}fac}$ be dealer i 's share of collateral pledged to money market funds that is not Fed-eligible over the December 1, 2007 to February 29, 2008 period, as reported in Table 4. This variable is intended to gauge the collateral on dealers' balance sheets before the facilities were introduced in March 2008. We modify Eq. (1) by including this additional variable to explain dealer behavior, so we have:

$$y_{it} = \alpha_0 + \gamma_t + \beta x_{it-1} + \delta Non - Fed - eligible_{i,pre\text{-}fac} + \varepsilon_{it}. \quad (5)$$

We also test specifications in which we allow interaction effects between our financial condition variables and our collateral variables, to test whether worse performing dealers are more likely to demand liquidity when they have greater shares of less liquid collateral:

$$y_{it} = \alpha_0 + \gamma_t + \beta x_{it-1} + \delta Non - Fed - eligible_{i,pre\text{-}fac} + \theta x_{it-1} * Non - Fed - eligible_{i,pre\text{-}fac} + \varepsilon_{it}. \quad (6)$$

The results in Table 10 show that the non-Fed-eligible collateral coefficient is positive and statistically significant for both the TSLF Schedule 2 (Columns 1 and 3) and PDCF (Columns 5 and 7).³⁵ The collateral coefficients are of similar magnitude in specifications including either equity return or leverage, and the coefficients on equity return and leverage generally remain significant.³⁶ The results suggest that dealers with less liquid collateral on their balance sheet before the crisis tended to borrow more from the facilities.

³⁵ We also report results in Appendix Table A5 based on a variable defined as each dealer's share of collateral pledged to money market funds that was non-Fed-eligible over the three-month period preceding an operation. Such results are similar to, but somewhat weaker than, the results using the share pledged to money market funds for the fixed three-month period before the facilities were introduced.

³⁶ For parsimony, we estimate the models on unconditional bid or borrowing amounts and not participation and conditional bid or borrowing amounts separately. For comparison, results for unconditional borrowing amounts excluding the collateral variables are reported in Appendix Table A6.

As with our other measures of dealer conditions, the effect of non-Fed-eligible collateral is not only statistically significant but also economically significant. Using the coefficients in Columns 1 and 5 of Table 10, we find that a one standard deviation positive shock to non-Fed-eligible collateral before the crisis (that is, an increase of 17 pp) increases a dealer's borrowing ratio in the Schedule 2 TSLF (in which the average ratio unconditional on participation is 20%) by 6 pp and PDCF borrowing amounts (in which the average unconditional borrowing amount is \$0.9 billion) by \$0.7 billion.

The results in Table 10 also show that the interaction terms between the collateral share variable and equity return are negative and significant for the PDCF (Columns 6 and 8), but of mixed sign and insignificant for the TSLF (Columns 2 and 4). The negative and significant coefficients for the PDCF imply that it is the combination of low equity returns and illiquid collateral that spurs dealers to borrow larger amounts, not either variable alone. The equity return and quasi-leverage variables lose individual significance when the interaction terms are included.

5.2. Short-term versus long-term borrowing

Aside from collateral, borrowing term was another key distinction between the TSLF and PDCF. TSLF loans were for 28 days, and PDCF loans were overnight. Aside from differences in collateral (discussed in Section 5.1) and borrowing fees (discussed Section 5.3), the length of time a dealer expected to need financing was likely a consideration in choosing which facility to borrow from. That is, even if the PDCF borrowing rate exceeded the implied TSLF borrowing rate, it can still have been cheaper for dealers with short-term funding needs to borrow from the PDCF instead of the TSLF. By rolling over their PDCF funding, firms could borrow for the number of days that they needed funds instead of commit to paying the fee for 28 days in the TSLF. The Fed did charge an additional fee to frequent PDCF borrowers (independent of the amount borrowed), which could have constrained such rollover funding.³⁷

In Table 11, we provide descriptive statistics on the extent of rollover funding of PDCF borrowers. We define a borrowing spell as the period of time over which a dealer's outstanding borrowing amount was positive. We find that nine of 18 PDCF borrowers had a mean spell length of at least 24 operation days. More striking than the mean, however, is the maximum, especially in comparison with the total number of borrowing days. For the 18 firms that borrowed from the PDCF, an average of 85% of all of their borrowing days came from a single spell (the ratio is 83% if we limit the sample to dealers that borrowed at least ten times). It appears that heavy users of the PDCF rolled over funding frequently, despite any additional fees they could have had to pay.³⁸

³⁷ We do not have information on the magnitude of the fees and are thus unable to determine the extent to which such fees affected dealer behavior.

³⁸ It follows that participation in a facility is highly predictive of future participation, especially for the PDCF. Appendix Table A7 reports results

Table 10

Effects of non-Fed eligible collateral.

The tables reports results of ordinary least squares bid or borrowing amount regressions for the Term Securities Lending Facility (TSLF) and Primary Dealer Credit Facility (PDCF). For each dealer and auction day, the TSLF dependent variable is the ratio of the total amount a dealer bid in a given auction to the maximum award amount. It is equal to zero if the dealer did not participate. The PDCF dependent variable is the amount borrowed from the PDCF on a given day, in tens of billions of dollars. Non-Fed-eligible is the percent share of collateral each dealer pledged to money market funds between December 1, 2007 and February 29, 2008 that is not US Treasury, agency debt, or agency mortgage-backed securities. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each operation. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% level, respectively.

Independent variable	Dependent variable: Unconditional bid amount							
	TSLF2				PDCF			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equity return	-0.511*** (0.104)	-0.557*** (0.160)			-0.414*** (0.116)	-0.006 (0.172)		
Equity return * Non-Fed-eligible		0.216 (0.629)				-1.889** (0.819)		
10/Quasi-leverage			-0.310** (0.116)	-0.224 (0.127)			-0.177 (0.118)	0.033 (0.076)
10/Quasi-leverage * Non-Fed-eligible				-0.732 (0.745)				-1.988** (0.818)
Non-Fed eligible	0.329** (0.149)	0.430** (0.189)	0.402** (0.167)	0.761 (0.529)	0.393** (0.138)	-0.362 (0.301)	0.433* (0.212)	1.577** (0.558)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.164 (0.107)	0.143 (0.115)	0.464*** (0.101)	0.428*** (0.113)	-0.225** (0.076)	-0.066 (0.066)	0.011 (0.047)	-0.126 (0.072)
Number of observations	739	739	738	738	5,954	5,954	5,945	5,945
Adjusted r-squared	0.403	0.403	0.356	0.364	0.277	0.324	0.239	0.306

Table 11

Primary Dealer Credit Facility (PDCF) spells analysis.

The table provides summary statistics on the distribution of the length (in business days) of PDCF borrowing spells by firm. The number of borrowing days is the number of days on which the dealer borrowed from the PDCF. For all firms, the number of borrowing days is the number of days on which at least one dealer borrowed from the PDCF. A spell is a period of time over which a borrower has a positive PDCF balance every day during the period. Average borrowing amounts are calculated over all operation days even if a dealer was not a primary dealer for some of those days.

Dealer	Number of borrowing days	Number of spells	Mean spell length	Median spell length	Minimum spell length	Maximum spell length	Average PDCF borrowing (millions of dollars)
Citigroup Global Markets Inc.	174	3	58.0	14	8	152	3,737.8
Deutsche Bank Securities Inc.	1	1	1.0	1	1	1	1.1
RBS Securities Inc.	0	0	N/A	N/A	N/A	N/A	0.0
Credit Suisse Securities (USA) LLC	2	1	2.0	2	2	2	3.2
Goldman, Sachs & Co.	52	2	26.0	26	1	51	922.6
Barclays Capital Inc.	74	3	24.7	24.0	1	49	873.3
Merrill Lynch Government Securities Inc.	99	4	24.8	2	1	95	3,164.1
UBS Securities LLC.	8	1	8.0	8	8	8	75.3
Morgan Stanley & Co. Incorporated	122	7	17.4	1	1	116	2,903.0
Banc of America Securities LLC	118	4	29.5	22	1	74	1,359.3
Lehman Brothers Inc.	10	3	3.3	3	1	6	177.3
J.P. Morgan Securities LLC	3	3	1.0	1	1	1	6.4
BNP Paribas Securities Corp.	43	9	4.8	3	1	13	141.2
Countrywide Securities Corporation	75	1	75.0	75.0	75	75	163.9
Bear, Stearns & Co., Inc.	69	1	69.0	69.0	69	69	2,042.8
Cantor Fitzgerald & Co.	61	1	61.0	61	61	61	59.7
HSBC Securities (USA) Inc.	0	0	N/A	N/A	N/A	N/A	0.0
Dresdner Kleinwort Securities LLC	1	1	1.0	1	1	1	0.2
Mizuho Securities USA Inc.	108	2	54.0	54	1	107	90.0
Daiwa Securities America Inc.	1	1	1.0	1	1	1	0.9
All firms	242	48	21.3	1.5	1	152	15,722.0

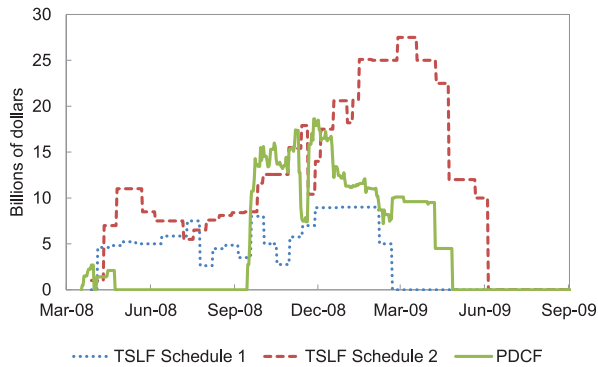


Fig. 5. Citigroup borrowing from Term Securities Lending Facility (TSLF) and Primary Dealer Credit Facility (PDCF). The figure plots Citigroup's outstanding borrowing from the TSLF (Schedules 1 and 2) and PDCF.

These borrowing patterns are illustrated in Fig. 5 for Citigroup, a heavy user of the PDCF. Citigroup rolled over its PDCF borrowing frequently at a time when it also borrowed extensively from the TSLF. In fact, 87% of Citigroup's PDCF borrowing days are accounted for by a single spell of 152 operation days starting September 15, 2008. The evidence suggests that dealers borrowed from the PDCF not because they valued the flexibility of shorter-term borrowing, but because they needed funds in addition to what they could obtain from the TSLF.

5.3. Cost of borrowing and stigma

The cost of borrowing across facilities sheds light on dealer preferences across the facilities, as well as between the facilities and the private market. Given that the PDCF was uniformly more flexible than the TSLF, one could expect that the auction-determined TSLF borrowing costs would have been uniformly lower than the cost of borrowing from the PDCF. Given that the only meaningful difference between TSLF Schedule 2 and Schedule 1 operations was the broader collateral eligibility in Schedule 2 operations, one would expect Schedule 1 costs to have been lower than Schedule 2. Lastly, because agency MBS collateral was the least liquid collateral accepted at Schedule 1 operations, one could expect the implied TSLF Schedule 1 borrowing cost to have equaled the agency MBS repo rate.

Facility borrowing costs and the one-month agency MBS repo rate are plotted in Fig. 6. Results are broadly consistent with the relations hypothesized above. That is, PDCF borrowing rates did in fact largely exceed implied TSLF Schedule 1 and Schedule 2 borrowing rates.³⁹ More-

of participation regressions in which participation over the preceding 20 business days is included as an independent variable. The inclusion of this variable eliminates statistical significance of the equity return coefficient for the PDCF, but the equity return and leverage coefficients remain significant (albeit smaller in magnitude) for the TSLF. The importance of prior participation can be explained by stigma (whereby a dealer is reluctant to participate if it has not previously, but is less hesitant if it has previously), although other persistent firm-specific attributes can also explain the pattern. We explore stigma in greater detail in Subsection 5.3.

³⁹ Implied TSLF borrowing rates are estimated as the TSLF stop-out rates plus the rate at the time on one-month Treasury general collateral repos.

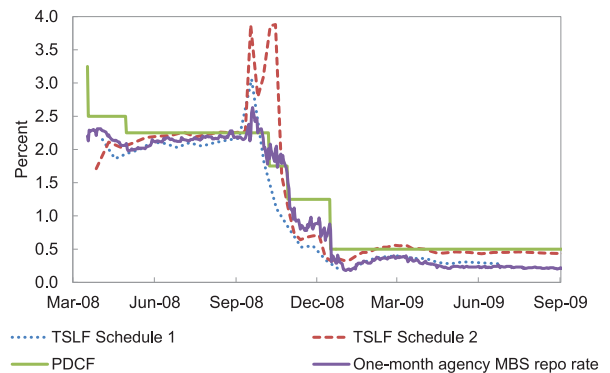


Fig. 6. Term Securities Lending Facility (TSLF) and Primary Dealer Credit Facility (PDCF) borrowing costs. The figure plots borrowing costs in the TSLF (Schedules 1 and 2) and PDCF, as well as the one-month agency mortgage-backed securities repo rate. TSLF borrowing costs are calculated as the one-month Treasury general collateral repo rate plus the stop-out rate for the given auction and schedule. PDCF borrowing costs equal the discount window primary credit rate.

over, TSLF Schedule 2 rates were uniformly above Schedule 1 rates. Lastly, TSLF Schedule 1 rates tended to track agency MBS repo rates closely.

However, the expected relations did not hold for the period after Lehman's failure. From October 2008 to January 2009, the agency MBS repo rate exceeded the implied TSLF Schedule 1 borrowing rate. That is, dealers were apparently willing to pay more to borrow in the private market than to borrow from the TSLF. The anomalous rate relation may be explained by stigma, despite the TSLF's auction design, as suggested by Krishnamurthy, Nagel, and Orlov (2014). However, heightened transaction costs of financing the borrowed Treasury collateral in the private market at the time could have also been a factor.⁴⁰

Also, the implied TSLF Schedule 2 borrowing rate exceeded the PDCF rate in September and October 2008. Such a relation does not suggest a stigma from borrowing from the Fed per se, but rather a stigma from borrowing from a standing facility as opposed to an auction facility. In fact, Armantier, Ghysels, Sarkar, and Shrader (2015) uncover just such a relation in their comparison of analogous facilities set up for depository institutions: the Term Auction Facility and the discount window. Armantier, Krieger, and McAndrews (2008) suggest that auction facilities could help overcome stigma because they allow firms to approach the Fed collectively instead of individually and because borrowing rates are set at auction and not at a premium by the Fed.

5.4. Interactions among dealer decisions to participate in different facilities

Our earlier regression analyses considered how dealers chose to participate in the PDCF and TSLF without regard for the fact that these participation decisions were not independent. However, dealers who borrowed heavily

⁴⁰ It is also possible that the reported agency MBS repo rate at the time was not representative due to illiquidity in the term repo market.

Table 12

Explaining bid or borrowing amounts, with seemingly unrelated regression model.

The table reports the results of bid or borrowing amount seemingly unrelated regressions for the Term Securities Lending Facility (TSLF) and Primary Dealer Credit Facility (PDCF) in which models 1, 4, and 7, 2, 5, and 8, and 3, 6, and 9 are estimated jointly. The TSLF Schedule 1 (Schedule 2) dependent variable is the ratio of the total amount a dealer bid in a given Schedule 1 (Schedule 2) auction to the maximum award amount, averaged over a two-week period. The PDCF dependent variable is the amount borrowed from the PDCF on a given day, in tens of billions of dollars, averaged over a two-week period. The dependent variables are not conditional on participation and are equal to zero when a dealer does not bid (TSLF) or borrow (PDCF). Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each two-week period. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each two-week period. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% level, respectively. Equity return and quasi-leverage coefficients marked ⁱⁱⁱ, ⁱⁱ, and ^j are jointly significant at the 1%, 5% and 10% level, respectively.

Independent variable	TSLF Schedule 1			TSLF Schedule 2			PDCF		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Equity return	-0.361*** (0.073)		-0.192** ^{ij} (0.094)	-0.500*** (0.050)		-0.494*** ^{ijii} (0.064)	-0.496*** (0.073)		-0.658*** ^{ij} (0.094)
10/Quasi-leverage		-0.338*** (0.063)	-0.231*** ^{ij} (0.082)		-0.284*** (0.046)	-0.008 ^{ij} (0.056)		-0.147** (0.066)	0.221*** ^{ij} (0.082)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.393*** -0.083	0.686*** (0.086)	0.568*** (0.104)	0.153*** (0.057)	0.463*** (0.062)	0.159** (0.071)	-0.110 (0.083)	0.127 (0.090)	-0.278*** (0.104)
Number of observations	536	536	536	536	536	536	536	536	536
Adjusted r-squared	0.290	0.295	0.300	0.340	0.268	0.340	0.248	0.191	0.258

from one facility tended to borrow heavily from another. We consider the simultaneous nature of dealers' decisions through a seemingly unrelated regression (SUR) analysis. The SUR analysis allows for correlated residuals across the different facility regressions. Although, in our application, there are no efficiency gains relative to least squares estimates because the same set of regressors appears in each equation, the SUR analysis allows us to compare marginal effects of dealer financial conditions across facilities and serves as a robustness test of our earlier results because of the requisite data aggregation.⁴¹

A difficulty in evaluating dealers' participation decisions is that the facilities operated at different times and provided for differing borrowing lengths. TSLF Schedule 1 and Schedule 2 operations both lent for 28 days, but the operations were mostly held in different weeks and mostly on different days when in the same week, so that the borrowing intervals almost always differed. In contrast, the PDCF lent funds daily on a standing basis. It follows that a dealer could replicate the TSLF lending periods through the PDCF, but it could not replicate either TSLF lending period with the other and it could not replicate PDCF lending periods through either schedule of the TSLF (except for the special case in which PDCF borrowing was known to be needed for the same 28 days as the TSLF lending period).

Our first step for the SUR analysis is to create a data set with synchronous observations (from underlying data that are not synchronous). We consider the 33 two-week periods from March 24, 2008 to June 26, 2009. Each period contains one TSLF Schedule 1 operation, one or more TSLF

Schedule 2 operations, and two weeks of business days on which firms could borrow from the PDCF. Our dependent variables are the average quantity of securities borrowed over each operation type in each two-week period (with quantity defined as earlier). Our equity return and quasi-leverage independent variables are measured as of the end of the preceding two-week period.

The SUR model is used to evaluate how dealers' returns and leverage affect their bidding amounts at TSLF auctions and the PDCF. The results, reported in Table 12, are qualitatively similar to our earlier least squares results, as should be expected given that differences arise only due to the data aggregation.⁴² In particular, TSLF Schedule 1 and Schedule 2 estimates are almost identical to those found with least squares regressions, whereas PDCF estimates are somewhat larger in magnitude and more significant.⁴³ Comparing estimates between facilities, we are unable to reject the null hypothesis, at standard significance levels, that the effects of the independent variables are the same for TSLF Schedule 1 and Schedule 2 operations.⁴⁴

5.5. Dealer financial performance and repo exposure

While the funding difficulties faced by dealers reflected the performance and liquidity of their assets, it could have also reflected the structure of their liabilities. While data limitations preclude an extensive analysis of this issue, we do examine, for a subset of dealers, the relation between

⁴¹ We also consider the simultaneous nature of dealers' decisions through unordered and ordered multinomial logit (ML) analyses. The unordered ML estimations incorporate inter-facility effects on dealers' choices by expanding dealers' choice set to participation in either of two different facilities or both or neither. The ordered ML estimation also allows for the following pecking order in choices: first, to participate or not, then participate in one of two facilities, and, finally, participate in both. We report these results in Appendix Tables A8 and A9.

⁴² Because we are explaining quantities borrowed, unconditional on participation, the comparable results are those reported in Appendix Table A6.

⁴³ The TSLF Schedule 1 coefficients should be identical, except for the fact that the independent variables are measured as of the end of the preceding two-week period in the case of the SUR, as opposed to the previous day in the case of least squares. This timing difference also explains why the SUR sample size is slightly larger than that for least squares.

⁴⁴ We do not test for differential effects between the PDCF and TSLF because of differences in units.

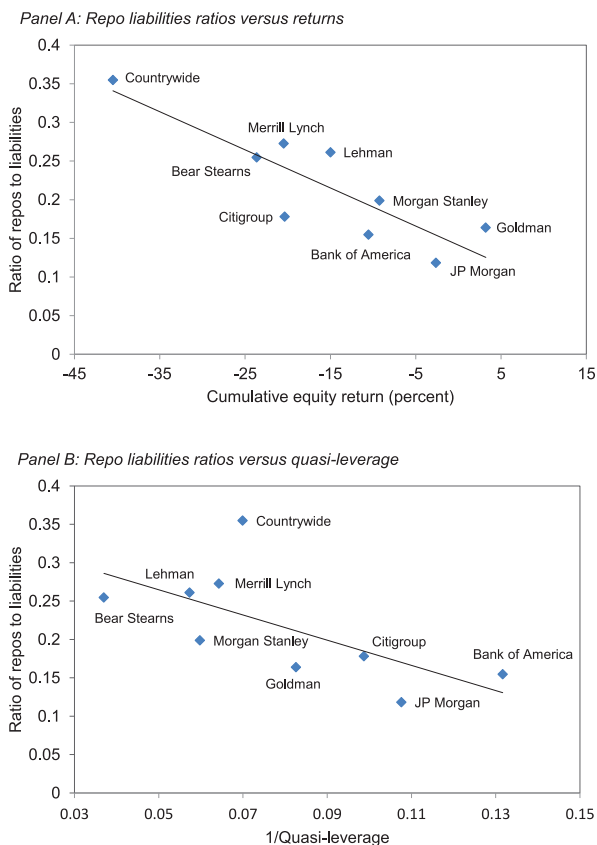


Fig. 7. Repo liabilities ratios versus financial conditions. The figure plots each dealer's average repo to liabilities ratio against its average cumulative equity return and quasi leverage between January 2, 2007 and March 16, 2008. The ratios are derived from quarterly balance sheet data as recorded in SNL Financial and are calculated as the sum of securities sold to repurchase and fed funds borrowings, divided by total liabilities. Equity returns are cumulated from January 2, 2007. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity. Due to differing accounting standards, foreign firms are excluded.

the financial condition measures we employ and the repo liabilities ratio, which is the ratio of the sum of securities sold to repurchase and fed funds borrowings to total liabilities.⁴⁵ We obtain data from the quarterly reports of dealer balance sheets as recorded in SNL Financial. We focus on the period from early 2007 until the failure of Bear Stearns (as the extent of repo liabilities post-Bear Stearns would be affected by the TSLF and the PDCF). Finally, we exclude foreign firms from this analysis due to differing accounting standards.

Panels A and B of Fig. 7 show the relation between the repo liabilities ratio and the two measures of financial conditions we employ in our analysis: cumulative equity return and the reciprocal of quasi-leverage. There appears to be a strong relation. Weaker US dealers (Countrywide, Bear Stearns, Merrill Lynch, and Lehman Brothers) had higher

⁴⁵ While dealers rely on other forms of short-term debt, such as commercial paper, reliable data on these other types are not publicly available.

repo liabilities ratios (25–35% range), and stronger US dealers (Goldman Sachs, Citigroup, J.P. Morgan, and Bank of America) had lower repo liabilities ratios (10–17.5% range). While more work is needed to understand the full determinants of dealer financial performance, Fig. 7 suggests that reliance on short-term wholesale funding in repo markets was a contributor, explaining both why the Fed created the TSLF and PDCF and why weaker dealers borrowed more from these facilities.

5.6. Effects of the facilities

While our primary focus is on the drivers of dealer participation in the facilities, a question of key importance to policy makers and others is whether the facilities improved the financial situation of dealers and the performance of the US financial system. A growing literature examines how the facilities affected particular financial markets (Fleming, 2012), but the broader effects are more difficult to discern. In the case of the TSLF, Fleming, Hrun, and Keane (2009, 2010) find that the operations were associated with a narrowing of repo spreads between less and more liquid collateral and Hrun and Seligman (2015) find that they were associated with narrower asset-backed commercial paper spreads. However, this work examined only a small number of money market spreads, reflecting limited data availability, making it difficult to draw broader inferences about the TSLF's effects.

Evidence on how the facilities affected financial institutions as opposed to markets is scarcer. Adrian, Burke, and McAndrews (2009) find that dealers' credit default swap spreads declined for three months following the program' introduction. However, their window of inquiry ends before the collapse of Lehman Brothers when credit default spreads widened across the board and numerous other developments over this period could have affected spreads.

As an alternative, we consider an event study approach, asking how the value of the dealers changed around key program announcement dates. Most announcement dates coincided with other important news, precluding clean identification of facility effects.⁴⁶ Accordingly, we conduct an analysis around March 11, 2008, when the TSLF was introduced, because no other significant events occurred on that date. We find that the equity performance of firms eligible to participate in the TSLF program rose 5.0% that day, on average, exceeding market performance [the S&P 500 rose 3.7% that day]. This result suggests that firm valuations reacted favorably to the introduction of the facility.

Moreover, a cross-sectional analysis shows that the equity performance of TSLF-eligible firms on March 11, 2008 was positively and significantly related to the share of collateral those firms pledged to money market funds that was not Fed-eligible over the preceding three months.⁴⁷

⁴⁶ In particular, the announcement of the PDCF on March 16, 2008 coincided with the near-failure of Bear Stearns, and the announcement of the broadening of eligible collateral in the facilities on September 14, 2008 coincided with the failure of Lehman Brothers.

⁴⁷ Each one standard deviation increase in non-Fed-eligible collateral was associated with an increase in equity return on March 11 of 1.9%, with the effect statistically significant at the 1% level.

We further find that this effect is concentrated in firms with poor equity performance since January 2007 (it is the interaction of non-Fed-eligible collateral share and the equity performance since January 2007 that matters).⁴⁸ Thus, some evidence exists that the valuation of firms with less liquid collateral reacted more positively to the announcement of the TSLF, suggesting that the market (correctly) anticipated that the program would especially benefit dealers with less liquid balance sheets.

6. Conclusion

Do central bank lender-of-last-resort facilities elicit greater and more aggressive participation from less capitalized financial firms? We address this question by examining financial conditions of dealers that participated in the Federal Reserve's Term Securities Lending Facility and Primary Dealer Credit Facility, LOLR facilities that provided liquidity against a range of assets as collateral during 2008–2009. We find that, in the cross section, dealers with more leverage and more negative returns prior to borrowing from the facilities were more likely to participate in the programs, borrow more, and, in the case of the TSLF, at higher bidding rates. Moreover, dealers with less liquid collateral on their balance sheets before the facilities were introduced also tended to borrow more. Further, interaction effects between financial performance and balance sheet liquidity seem to have been especially important in explaining dealer behavior. Finally, the effect of a decrease in the health of a dealer was to depress participation by other

dealers (in TSLF auctions), suggesting that weaker dealers crowded out stronger dealers (who presumably had more attractive financing options elsewhere).

Our results demonstrate important composition effects in the behavior of financial firms when central banks lend against illiquid collateral. These effects are consistent with the important trade-offs that central banks face in their lender-of-last-resort role. In particular, the results are consistent with the incentive-based argument for the [Bagehot \(1873\)](#) recommendation that central banks lend only against high quality collateral. While Bagehot's original concern was primarily with the growth of the central bank's balance sheet, Bagehot's recommendation can be pertinent in the modern context when such growth is somewhat of a lesser concern, and the primary concern, as with recent financial crises, is the delay in private recapitalization or adequate de-leveraging and de-risking by financial firms.

Central banks do attempt to limit participation in their facilities to financial firms based on prior financial health and also monitor participants on an ongoing basis. Central banks also impose higher haircuts for more illiquid collateral. However, such haircuts are typically not greater for weaker borrowers. Further, in a crisis situation, financial conditions change rapidly and regulators face the difficult challenge of knowing which signals to rely on. Our results suggest that, through the crisis, market-based signals of dealer financial conditions continued to provide useful predictive information on dealer participation in Fed facilities and, thus, indirectly on the need to fund lower quality, illiquid collateral.

⁴⁸ When regressing March 11 equity returns of eligible firms on their equity performance, non-Fed-eligible, and interaction variables (as well as a constant), the interaction term is the only significant determinant (at the 5% level of significance).

Appendix

Table A1

TSLF auction results.

Auction date	Schedule	Term	Offer amount	Submitted amount	Accepted amount	Bid-to-cover	Stop-out rate
27-03-2008	2	28	75	86.1	75.0	1.15	33
03-04-2008	1	28	25	46.9	25.0	1.88	16
10-04-2008	2	28	50	34.0	34.0	0.68	25
17-04-2008	1	28	25	35.1	25.0	1.40	10
24-04-2008	2	28	75	59.5	59.5	0.79	25
01-05-2008	1	28	25	24.1	24.1	0.96	10
08-05-2008	2	28	50	28.8	28.8	0.58	25
15-05-2008	1	28	25	7.2	7.2	0.29	10
22-05-2008	2	28	75	46.1	46.1	0.62	25
29-05-2008	1	28	25	16.4	16.4	0.66	10
05-06-2008	2	31	50	26.9	26.9	0.54	25
12-06-2008	1	28	25	27.2	25.0	1.09	10
19-06-2008	2	28	75	36.8	36.8	0.49	25
26-06-2008	1	28	25	15.4	15.4	0.62	11
03-07-2008	2	25	50	26.1	26.1	0.52	25
10-07-2008	1	28	25	21.3	21.3	0.85	10
17-07-2008	2	28	75	51.8	50.8	0.69	25
24-07-2008	1	28	25	51.7	25.0	2.07	12
31-07-2008	2	28	50	28.1	28.1	0.56	25
07-08-2008	1	28	25	39.5	25.0	1.58	13
14-08-2008	2	28	75	39.3	39.3	0.52	25
21-08-2008	1	28	25	44.7	25.0	1.79	14
28-08-2008	2	28	50	26.7	26.7	0.53	25
04-09-2008	1	28	25	45.0	25.0	1.80	15
11-09-2008	2	28	75	40.9	40.9	0.54	25
17-09-2008	2	14	35	64.4	35.0	1.84	250
17-09-2008	2	28	35	71.3	35.0	2.04	300
18-09-2008	1	28	25	49.6	25.0	1.98	151
25-09-2008	2	27	38	61.2	37.5	1.63	102
01-10-2008	2	28	35	66.7	35.0	1.90	151
02-10-2008	1	28	25	49.0	25.0	1.96	42
09-10-2008	2	27	38	62.8	37.5	1.67	305
15-10-2008	2	28	38	73.7	37.5	1.96	322
16-10-2008	1	28	25	44.0	25.0	1.76	46
22-10-2008	2	28	38	47.3	37.5	1.26	50
29-10-2008	2	29	38	53.1	37.5	1.42	38
30-10-2008	1	28	25	30.8	25.0	1.23	12
05-11-2008	2	28	38	43.0	37.5	1.15	25
12-11-2008	2	28	38	35.1	35.1	0.94	25
13-11-2008	1	28	25	17.6	17.6	0.70	10
19-11-2008	2	28	38	32.5	32.5	0.87	25
26-11-2008	1	28	25	31.0	25.0	1.24	10
26-11-2008	2	28	38	37.7	37.5	1.00	25
03-12-2008	2	29	38	45.6	37.5	1.21	31
10-12-2008	2	28	38	26.9	26.9	0.72	25
11-12-2008	1	28	25	23.0	23.0	0.92	10
17-12-2008	2	28	38	25.7	25.7	0.69	25
24-12-2008	1	28	25	22.0	22.0	0.88	10
24-12-2008	2	27	38	29.5	29.5	0.79	25
31-12-2008	2	27	38	28.8	28.8	0.77	25
07-01-2009	2	28	38	15.5	15.5	0.41	25
08-01-2009	1	28	25	9.5	9.5	0.38	10
14-01-2009	2	28	38	27.9	27.9	0.74	25
21-01-2009	2	28	38	25.8	25.8	0.69	25
22-01-2009	1	28	25	17.0	17.0	0.68	10
28-01-2009	2	28	38	25.0	25.0	0.67	25
04-02-2009	2	28	38	14.0	14.0	0.37	25
05-02-2009	1	28	25	6.8	6.8	0.27	10
11-02-2009	2	28	38	26.9	26.8	0.72	25

(continued on next page)

Table A1 (continued)

Auction date	Schedule	Term	Offer amount	Submitted amount	Accepted amount	Bid-to-cover	Stop-out rate
18-02-2009	2	28	38	23.8	23.8	0.63	25
19-02-2009	1	28	25	15.0	15.0	0.60	10
25-02-2009	2	28	38	25.9	25.9	0.69	25
04-03-2009	2	28	38	11.2	11.2	0.30	25
05-03-2009	1	28	25	5.5	5.5	0.22	10
11-03-2009	2	28	38	24.8	24.8	0.66	25
18-03-2009	2	28	38	18.2	18.2	0.49	25
19-03-2009	1	28	25	3.0	3.0	0.12	11
25-03-2009	2	28	38	23.0	23.0	0.61	25
01-04-2009	2	21	38	6.2	6.2	0.17	25
02-04-2009	1	28	25	0.0	0.0	0.00	10
08-04-2009	2	28	38	9.4	9.4	0.25	25
15-04-2009	2	21	38	5.0	5.0	0.13	25
16-04-2009	1	28	25	0.0	0.0	0.00	10
22-04-2009	2	29	75	18.2	18.2	0.24	25
30-04-2009	1	28	25	0.0	0.0	0.00	10
06-05-2009	2	29	75	14.4	14.4	0.19	25
14-05-2009	1	28	25	0.0	0.0	0.00	10
21-05-2009	2	28	75	13.0	13.0	0.17	25
28-05-2009	1	28	25	0.0	0.0	0.00	10
04-06-2009	2	27	75	2.8	2.8	0.04	25
11-06-2009	1	28	25	0.0	0.0	0.00	10
18-06-2009	2	28	75	4.0	4.0	0.05	25
25-06-2009	1	28	25	0.0	0.0	0.00	10
01-07-2009	2	15	38	0.3	0.3	0.01	25
16-07-2009	2	28	75	2.7	2.7	0.04	25
13-08-2009	2	28	75	0.0	0.0	0.00	25
10-09-2009	2	28	75	0.0	0.0	0.00	25
08-10-2009	2	28	50	0.0	0.0	0.00	25
05-11-2009	2	28	25	0.0	0.0	0.00	25
03-12-2009	2	35	25	0.0	0.0	0.00	25
07-01-2010	2	28	25	0.0	0.0	0.00	25

Note: The table reports data for all 91 auctions over the life of the Term Securities Lending Facility. Terms are in days, amounts are in billions of dollars, par value, and rates are in basis points.

Table A2
Explaining whether a dealer participates (with probit model).

	TSLF Schedule 1			TSLF Schedule 2			PDCF		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Equity return	-1.774** (0.838)		-0.596 ^{ij} (1.012)	-3.271*** (0.907)		-2.502*** ^{ijj} (1.011)	-2.721** (1.280)		-4.054*** ^{ijj} (1.429)
10/Quasi-leverage		-2.248** (0.910)	-1.891 ^{ij} (1.062)		-2.601*** (0.847)	-1.089 ^{ijj} (0.868)		-0.908 (1.024)	1.753 ^{ij} (1.149)
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.136 (0.441)	1.814*** (0.554)	1.464* (0.818)	0.155 (0.488)	2.606*** (0.460)	1.022* (0.606)	-1.967*** (0.574)	-0.358 (0.637)	-3.329*** (1.044)
Observations	429	428	428	828	827	827	3,918	3,916	3,916
Pseudo R-squared	0.206	0.235	0.239	0.281	0.247	0.289	0.211	0.115	0.235

Notes: The table reports the results of probit participation regressions for the TSLF and PDCF. The TSLF Schedule 1 (Schedule 2) dependent variable is an indicator variable equal to one if a dealer submitted a bid in a Schedule 1 (Schedule 2) auction and zero otherwise. The PDCF dependent variable is an indicator variable equal to one if a dealer borrowed from the PDCF on a given day and zero otherwise. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each operation. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% levels, respectively. Equity return and quasi-leverage coefficients marked ^{ijj}, ^{ij}, and ^j are jointly significant at the 1%, 5% and 10% levels, respectively.

Table A3
Explaining bid/borrowing amounts, conditional on participation (with Tobit model).

	TSLF Schedule 1			TSLF Schedule 2		
	(1)	(2)	(3)	(4)	(5)	(6)
Equity return	−0.351 (0.415)		−0.300 (0.581)	−0.558*** (0.187)		−0.639** ^{ij} (0.279)
10/Quasi-leverage		−0.240 (0.512)	−0.079 (0.685)		−0.273 (0.187)	0.129 ^{ij} (0.263)
Time fixed effects	YES	YES	YES	YES	YES	YES
Constant	1.006*** (0.323)	0.798*** (0.196)	0.846* (0.496)	0.517*** (0.130)	0.199* (0.109)	0.112 (0.233)
Observations	189	188	188	409	408	408
Pseudo R-squared	0.105	0.0999	0.104	0.397	0.478	0.481

Notes: The table reports the results of Tobit bid amount regressions for the TSLF. The TSLF Schedule 1 (Schedule 2) dependent variable is the ratio of the total amount a dealer bid/borrowed in a given Schedule 1 (Schedule 2) auction to the maximum award amount, and is right-censored at one. The dependent variables are conditional on participation and hence undefined when a dealer does not bid. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each operation. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% levels, respectively. Equity return and quasi-leverage coefficients marked ^{ij}, ^{ij}, and ^j are jointly significant at the 1%, 5% and 10% levels, respectively.

Table A4
Explaining bid rates (with Tobit model).

	TSLF Schedule 1			TSLF Schedule 2		
	(1)	(2)	(3)	(4)	(5)	(6)
Equity return	−0.376* (0.207)		−0.155 ^{ijj} (0.239)	−3.174** (1.357)		−3.371 ^{ij} (2.236)
10/Quasi-leverage		−0.606*** (0.174)	−0.541** ^{ijj} (0.228)		−1.890** (0.934)	0.261 ^{ij} (1.804)
Time fixed effects	YES	YES	YES	YES	YES	YES
Constant	−0.049 (6.526)	0.327*** (9.497)	0.251* (14.798)	−0.142 (0.536)	1.827*** (0.585)	−0.329 (1.560)
Observations	189	188	188	409	408	408
Pseudo R-squared	0.0861	0.0916	0.0921	0.178	0.149	0.178

Notes: The table reports results of Tobit bid rate regressions for the TSLF. The dependent variable is the bid rate, which is left-censored at 0.1 for Schedule 1 auctions and 0.25 for Schedule 2 auctions. If a dealer submitted two bids in an auction, then the dependent variable equals the average bid rate weighted by bid amount. The dependent variable is undefined if a dealer did not submit any bids. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each auction. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each auction. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% levels, respectively. Equity return and quasi-leverage coefficients marked ^{ijj}, ^{ij}, and ^j are jointly significant at the 1%, 5% and 10% levels, respectively.

Table A5
Effects of dynamic MMF non-Fed eligible collateral.

Dependent variable: unconditional bid amount	TSLF2				PDCF			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equity return	-0.450*** (0.111)	-0.439*** (0.118)			-0.327** (0.117)	-0.234 (0.148)		
Equity return* non-Fed eligible		-0.098 (0.303)				-0.874 (0.921)		
10/Quasi-leverage			-0.248** (0.096)	-0.227** (0.095)			-0.102 (0.068)	-0.024 (0.058)
10/Quasi-leverage * non-Fed eligible				-0.338 (0.830)				-1.389 (1.052)
Dynamic MMF non-Fed eligible	0.417** (0.152)	0.371* (0.173)	0.491** (0.194)	0.628 (0.430)	0.305 (0.197)	-0.080 (0.271)	0.354 (0.217)	0.944 (0.658)
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.162 (0.118)	0.169 (0.117)	0.412*** (0.109)	0.411*** (0.108)	-0.174** (0.078)	-0.130* (0.069)	-0.010 (0.046)	-0.029 (0.060)
Observations	753	753	752	752	6,156	6,156	6,147	6,147
Adjusted R-squared	0.393	0.392	0.346	0.346	0.248	0.254	0.215	0.226

Notes: The table reports results of OLS bid amount regressions for the PDCF and TSLF2. The TSLF Schedule 2 dependent variable is the ratio of the total amount a dealer bid in a given Schedule 2 auction to the maximum award amount. The PDCF dependent variable is the amount borrowed from the PDCF on a given day, in tens of billions of dollars. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each operation. MMF Non-Fed Eligible is the share of collateral each dealer pledged to money market funds that is not US Treasury, agency debt, or agency mortgage-backed securities in the three-month window before each auction. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% levels, respectively.

Table A6
Explaining bid/borrowing amounts (Unconditional on participation).

	TSLF Schedule 1			TSLF Schedule 2			PDCF		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Equity return	-0.384** (0.165)		-0.232 ^{ij} (0.254)	-0.515*** (0.125)		-0.502*** ^{ijj} (0.157)	-0.286** (0.126)		-0.342*** ^{ij} (0.127)
10/Quasi-leverage		-0.319** (0.144)	-0.192 ^{ij} (0.254)		-0.294** (0.105)	-0.017 ^{ijj} (0.112)		-0.085 (0.064)	0.083 ^{ij} (0.051)
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.402*** (0.118)	0.671*** (0.129)	0.542** (0.240)	0.152 (0.097)	0.468*** (0.084)	0.165 (0.134)	-0.097* (0.052)	0.057 (0.034)	-0.158** (0.066)
Observations	534	533	533	912	911	911	7,286	7,277	7,277
Adjusted R-squared	0.294	0.243	0.250	0.331	0.267	0.329	0.182	0.152	0.185

Notes: The table reports the results of OLS bid/borrowing amount regressions for the TSLF and PDCF. The TSLF Schedule 1 (Schedule 2) dependent variable is the ratio of the total amount a dealer bid in a given Schedule 1 (Schedule 2) auction to the maximum award amount. The PDCF dependent variable is the amount borrowed from the PDCF on a given day, in tens of billions of dollars. The dependent variables are not conditional on participation and are equal to 0 when a dealer does not bid (TSLF) or borrow (PDCF). Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each operation. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% levels, respectively. Equity return and quasi-leverage coefficients marked ^{ijj}, ^{ij}, and ^j are jointly significant at the 1%, 5% and 10% levels, respectively.

Table A7
Explaining dealer participation with prior participation.

	TSLF Schedule 1			TSLF Schedule 2			PDCF		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Prior bidding	0.660*** (0.057)	0.635*** (0.048)	0.632*** (0.055)	0.768*** (0.051)	0.728*** (0.060)	0.745*** (0.058)	0.933*** (0.019)	0.928*** (0.018)	0.931*** (0.019)
Equity return		-0.152** (0.066)			-0.180** (0.074)			-0.019 (0.019)	
10/Quasi-leverage			-0.128** (0.056)			-0.116** (0.048)			0.007 (0.009)
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.213** (0.077)	0.216** (0.097)	-0.004 (0.094)	-0.011 (0.064)	-0.106 (0.074)	0.073** (0.027)	0.019 (0.014)	0.012 (0.021)	0.016 (0.012)
Observations	502	498	497	882	876	875	6,730	6,705	6,703
Adjusted R-squared	0.513	0.515	0.513	0.581	0.589	0.586	0.815	0.810	0.810

Notes: The table reports the results of OLS participation regressions for the TSLF and PDCF. The TSLF Schedule 1 (Schedule 2) dependent variable is an indicator variable equal to one if a dealer submitted a bid in a Schedule 1 (Schedule 2) auction and zero otherwise. The PDCF dependent variable is an indicator variable equal to one if a dealer borrowed from the PDCF on a given day and zero otherwise. Prior bidding is defined as the number of operations in which a dealer participated over the previous 20 business days, divided by the number of operations over those days. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to market value of equity as of the day preceding each operation. Standard errors clustered by dealer are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5% and 10% levels, respectively.

Table A8
Probability of dealer participation in one or two facilities, relative to non-participation: multinomial logit model.

Panel A. TSLF Schedule 1 and PDCF compared									
	TSLF Schedule 1 only			PDCF only			Both		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Equity return	-2.794*** (0.703)		-0.386 (0.903)	-3.174*** (0.864)		-6.512*** (1.369)	-5.834*** (0.918)		-5.945*** (1.175)
10/Quasi-leverage		-4.225*** (0.726)	-4.005*** (0.905)		-0.426 (0.804)	4.233*** (1.318)		-3.467*** (0.819)	0.128 (1.067)
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	-0.252 (0.614)	2.617*** (0.748)	2.360*** (0.876)	-18.37 (3.083)	-18.96 (6.729)	-22.57 (3.842)	-1.388* (0.710)	2.125*** (0.785)	-1.508 (1.080)
Observations	534	533	533	534	533	533	534	533	533
Log likelihood	-440.29	-442.77	-417.86	-440.29	-442.77	-417.86	-440.29	-442.77	-417.86
Panel B. TSLF Schedule 2 and PDCF compared									
	TSLF Schedule 2 only			PDCF only			Both		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Equity return	-5.773*** (0.616)		-4.615*** (0.789)	-3.522*** (0.832)		-8.216*** (1.263)	-9.179*** (0.821)		-11.40*** (1.128)
10/Quasi-leverage		-4.455*** (0.530)	-1.781*** (0.683)		0.590 (0.734)	5.934*** (1.167)		-3.898*** (0.631)	2.902*** (0.949)
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	-0.158 (0.700)	3.820*** (0.815)	1.066 (0.872)	-18.49 (4.241)	-17.83 (3.409)	-23.37 (3.180)	-1.779** (0.818)	3.151*** (0.860)	-4.147*** (1.148)
Observations	912	911	911	912	911	911	912	911	911
Log likelihood	-754.06	-795.15	-732.10	-754.06	-795.15	-732.10	-754.06	-795.15	-732.10

Notes: The table reports the log odds ratio of participating in one or two facilities, relative to non-participation in any facility. The estimation method is multinomial logit with participation outcomes as the dependent variable. The base category is non-participation in any facility. The remaining categories are participation in TSLF Schedule 1 (Panel A) or Schedule 2 (Panel B) only, PDCF only, or both. TSLF1 (TSLF2) participation is defined as submitting a bid in a Schedule 1 (Schedule 2) auction. PDCF participation is defined as borrowing from the PDCF at any time during the 28-day period following a TSLF Schedule 1 (Panel A) or Schedule 2 (Panel B) auction. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to the market value of equity as of the day preceding each operation. Standard errors are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5%, and 10% levels, respectively.

Table A9

Probability of dealer participation in one facility, relative to non-participation, and in both facilities, relative to participation in one facility: ordered logit model.

Panel A. TSLF schedule 1 and PDCF compared			
	TSLF schedule 1 & PDCF		
	(1)	(2)	(3)
Equity return	−3.282*** (0.488)		−3.471*** (0.618)
10/Quasi-leverage		−1.641*** (0.447)	0.317 (0.571)
Time fixed effects	YES	YES	YES
Observations	534	533	533
Log likelihood	−498.79	−515.04	−498.42

Panel B. TSLF schedule 2 and PDCF compared			
	TSLF schedule 2 & PDCF		
	(1)	(2)	(3)
Equity return	−4.387*** (0.394)		−5.372*** (0.541)
10/Quasi-leverage		−1.952*** (0.340)	1.302*** (0.467)
Time fixed effects	YES	YES	YES
Observations	912	911	911
Log likelihood	−838.24	−889.44	−834.27

Notes: The table reports the log odds ratio of participating in one facility, relative to non-participation in any facility, and participation in both facilities, relative to participating in one facility. The estimation method is the ordered multinomial logit with participation outcomes as the dependent variable. The outcomes are ordered as follows: 0 is non-participation in any facility, 1 is participation in TSLF Schedule 1 only (Panel A), or in TSLF Schedule 2 only (Panel B), 2 is participation in the PDCF only, and 3 is defined as participation in both facilities. TSLF1 (TSLF2) participation is defined as submitting a bid in a Schedule 1 (Schedule 2) auction. PDCF participation is defined as borrowing from the PDCF at any time during the 28 days following a TSLF Schedule 1 (Panel A) or TSLF Schedule 2 (Panel B) auction. Cumulative equity returns are calculated for each firm from January 2, 2007 to the day preceding each operation. Quasi-leverage is the ratio of a firm's quasi-market value of assets (i.e., the market value of equity plus the book value of debt) to the market value of equity as of the day preceding each operation. Standard errors are reported in parentheses. Coefficients marked ***, **, and * are significant at the 1%, 5%, and 10% levels, respectively.

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