Repo Market Effects of the Term Securities Lending Facility*

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First draft: December 16, 2008
This draft: April 25, 2009

Abstract

The Term Securities Lending Facility (TSLF) was recently introduced by the Federal Reserve to promote liquidity in the financing markets for Treasury and other collateral. We evaluate one aspect of the program – the extent to which it has narrowed repo spreads between Treasury collateral and lower quality collateral. We find that TSLF operations have precipitated a significant narrowing of repo spreads. More refined tests indicate the market conditions and types of operations associated with the program's effectiveness. Various additional tests, including a split sample test, suggest that our findings are robust.

Keywords: Federal Reserve, liquidity facility, repo market, repurchase agreement

JEL Codes: G12, G14, E52, E58, E43

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* We thank Tobias Adrian, Charles Jones, Carol Osler and seminar participants at Brandeis University, the ASSA Annual Meetings, the Federal Reserve Bank of New York Conference on Central Bank Liquidity Tools, and RiskMetrics for helpful comments. We thank Nicholas Klagge for excellent research assistance. Views expressed are those of the authors and not necessarily those of the Federal Reserve Bank of New York or the Federal Reserve System.

1. Introduction

On March 11, 2008, the Federal Reserve introduced the Term Securities Lending Facility "to promote liquidity in the financing markets for Treasury and other collateral and thus to foster the functioning of financial markets more generally."[1] Financing markets play a crucial role in the efficient allocation of capital in financial markets and are widely used by dealers to finance their market-making, risk-management, and speculative activities. In early 2008, however, these markets became severely impaired. Lenders reduced the amount they were willing to lend for a given amount of collateral, demanded greater compensation for lending against riskier collateral, or halted lending against certain types of collateral altogether.

The TSLF is intended to address liquidity disruptions in financing markets by enabling dealers to swap less liquid collateral, which is harder to finance, for more liquid Treasury collateral, which is easier to finance. Specifically, the facility allows dealers with a trading relationship with the Federal Reserve Bank of New York, so-called primary dealers, to bid a fee to borrow a certain quantity of Treasury securities from the Fed for 28 days, while agreeing to provide other securities as collateral. Dealers can then use the borrowed Treasury securities as collateral to obtain cash in the private market. The economic rationale for the TSLF is captured by Kiyotaki and Moore (2008), who demonstrate the conditions under which a government should offset a liquidity shock by swapping money (liquid securities) for less liquid assets.

We assess the effects of the TSLF by examining the extent to which it narrowed repurchase agreement (repo) spreads between Treasury collateral and lower quality

[1] See the Federal Reserve press release announcing the TSLF, <http://www.federalreserve.gov/newsevents/press/monetary/20080311a.htm>.

collateral. We do this by relating changes in repo rates and spreads to changes in the quantities of securities available to the private market because of the TSLF. We further relate these changes to the types of securities provided as collateral and whether a TSLF auction was undersubscribed or not, and we condition the effects on the level of repo rates.

We find that the TSLF has precipitated a significant narrowing of repo spreads. The narrowing we observe can be attributed, in particular, to higher Treasury repo rates as opposed to lower rates on lower quality collateral. We find that the results are driven by fully subscribed operations, operations at which a broader set of collateral is eligible, and operations conducted when the Treasury repo rate is far below the fed funds target rate. Various additional tests, including a split sample test, suggest that our findings are robust.

Our paper is most related to work by McAndrews, Sarkar, and Wang (2008), Wu (2008), Christensen, Lopez, and Rudebusch (2009), and Taylor and Williams (2009), who examine the effects of the Term Auction Facility (TAF) on term spreads in the unsecured funding markets.[2] While some of these studies conclude that the TAF lowers term spreads, Taylor and Williams find that the evidence of a significant effect is not robust. One reason for this, offered by Taylor and Williams, is because the TAF does not increase the net supply of bank reserves, with increases in reserves due to borrowing from the TAF offset by decreases in reserves from Fed sales of securities.

Our analysis of the TSLF may provide for a stronger test of liquidity facility effects. First, borrowing from the TSLF does in fact cause a net increase in the quantity of Treasury collateral in the market and a net decrease in the quantity of other collateral. Moreover, the

[2] Wu (2008) also examines the effects of the TSLF, but his analysis focuses on the TAF and term spreads. Fleming, Hrung, and Keane (2009) describe the origins and design of the TSLF, but only look at the effects of the first 10 operations and do not perform a statistical analysis. Another related paper is Sundaresan and Wang (2009), who examine the effect of Y2K options on Treasury liquidity premia.

overnight repo rates and spreads we examine are highly sensitive to the floating supply of underlying securities in the market on that day, and insensitive to expectations about future changes in supply, so that changes in security supply from a particular TSLF operation can be considered exogenous. In contrast, endogeneity may be a greater concern with analyses of the TAF, perhaps explaining why those analyses employ varied empirical approaches.

Our paper is more broadly related to the literature assessing supply effects. Krishnamurthy and Vissing-Jorgensen (2008) show that the debt/GDP ratio is negatively correlated with corporate spreads, which reflect a convenience yield investors attribute to Treasury securities. Greenwood and Vayanos (2008) show that the supply of long- relative to short-term debt is positively related to the term spread. Several additional papers show that Treasury issue sizes are positively related to yields (e.g., Simon (1991, 1994), Duffee (1996), and Fleming (2002)). In contrast to these papers, however, we relate the underlying supply of securities to the cost of financing those securities.

The paper is also related to work on the repo market by Duffie (1996), Jordan and Jordan (1997), Krishnamurthy (2002), and others. Such work is primarily concerned with special collateral repos, in which the motivation for the transaction is to lend a particular security as opposed to general collateral repos, in which the motivation is to borrow money Effective security supply is an important feature of "specials" markets (see, e.g., Jordan and Jordan (1997)). One paper on the specials market by Fleming and Garbade (2007) assesses dealer behavior in the Fed's existing securities lending facility, in which dealers can bid to borrow particular Treasury securities, while providing other Treasuries as collateral. Longstaff (2000) assesses the term structure of general collateral Treasury repo rates and finds that such rates support the expectations hypothesis.

The paper is organized as follows. In Section 2, we provide background on the repo market, the introduction of the TSLF, and how the TSLF works. Section 3 explains the hypotheses we test. Section 4 describes the data used in our analysis, including descriptive information on the TSLF operations. Our empirical results are presented in Section 5. Section 6 concludes.

2. The Term Securities Lending Facility

A. Background on the Repo Market

A repurchase agreement is a sale of securities coupled with an agreement to repurchase the same securities on a later date, typically at a higher price. A repo is thus broadly similar to a collateralized loan. As with a collateralized loan, the lender of funds has possession of the borrower's securities over the term of the loan and can sell them if the borrower defaults on its obligation.

A *general collateral* repo is one in which the lender of funds is willing to accept any of a variety of securities as collateral. The class of acceptable collateral might be limited to Treasury securities, or it might include other types of securities, such as agency debt securities. The lender is concerned primarily with earning interest on its money and having possession of assets that can be sold quickly with minimal transaction costs in the event of a default by the borrower. Interest rates on overnight general collateral repos are usually quite close to rates on overnight loans in the federal (fed) funds market, reflecting the essential character of a general collateral repo as a device for borrowing and lending money.[3]

[3] A *special collateral* repo, in contrast, is one in which the lender of funds designates a particular security as the only acceptable collateral and is, consequently, a device for borrowing and lending *securities*. Special collateral repos are explained in Duffie (1996), Keane (1996), Jordan and Jordan (1997), and elsewhere.

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.

Repos are also frequently used in open market operations (OMOs) by the Fed (see, e.g., Edwards (1997)). Open market operations affect the supply of reserve balances in the banking system and thereby influence short-term interest rates. If the Fed wants to add reserves on a temporary basis, for example, it can purchase securities from dealers while agreeing to resell them on a later date. Most repos are arranged with a one-day term, but longer-term repos, commonly seven or 14 days, are also conducted. The Fed accepts three types of collateral in its repos, Treasury securities, agency debt securities, and agency mortgage-backed securities (MBS).

An important feature of repos is the "haircut" imposed by the lender of funds. The haircut is the percentage difference between the market value of the pledged collateral and the amount of funds lent. A haircut of 5%, for example, implies that a dealer can borrow $95 for each $100 in pledged collateral. A haircut further protects the lender of funds against the risk of borrower default. The size of the haircut reflects the credit risk of the borrower and the riskiness of the pledged collateral.

B. Introduction of the TSLF

While dealers normally rely on the private markets to finance their positions, such markets became severely impaired in early 2008. Lenders of funds became increasingly

concerned about losing money on repurchase agreements 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 – or by halting lending against certain types of collateral altogether.[4]

Another response was for lenders to demand greater compensation for lending against riskier collateral. As shown in Figure 1, overnight agency and agency MBS financing spreads to Treasury have historically been quite narrow, averaging 7 and 8 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 in the second half of 2007 and averaged 55 and 62 basis points, respectively, over January and February of 2008. Repo spreads for lower quality collateral are not available, but 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 is unable to borrow elsewhere and sales of securities are infeasible because of market illiquidity, however, a dealer might 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.[5]

It was in this environment of funding market stress that the TSLF was introduced. The facility allows primary dealers to bid a fee to borrow a certain quantity of Treasury

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[4] See, for example, "Repo Market Funding," *Financial Times*, March 11, 2008 and "Another Source of Quick Cash Dries Up – Firms Rethink Reliance on 'Repo' Financing as Conditions Tighten," *Wall Street Journal*, C1, March 17, 2008.

[5] See, for example, "The Bear Stearns Fallout: With Street Watching, 'Repo' Trading Is Light – Market That Turned on Bear Stearns Remains Cautious," *Wall Street Journal*, C6, March 18, 2008, and "TSLF Auction Could Be the Light at the End of the Repo Tunnel," *Financial Times*, March 27, 2008.

securities from the Fed for a term of 28 days, while agreeing to provide other securities as collateral. That is, collateral which may be difficult to finance can 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 TSLF thereby increases 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 TSLF should reduce 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 TSLF should also reduce funding pressures on the dealers, reducing the likelihood of a loss of confidence among lenders.

The TSLF could also be expected to affect the functioning of financing markets directly. The exchange of collateral facilitated by the TSLF increases the supply of Treasury collateral in the market and reduces the supply of less liquid collateral in the market. The changes in supply should reduce the private market costs of financing less liquid collateral relative to Treasury collateral. Moreover, by providing dealers the opportunity to finance less liquid collateral, the TSLF should increase dealer willingness to make markets in the less liquid collateral for their customers.

C. How the TSLF Works

Treasury collateral made available through the TSLF is allocated via auction. The day before each auction, the Fed announces the par value of the offering amount, the particular basket of Treasury securities it is willing to lend, and the collateral eligible for delivery against the Treasury securities. “Schedule 1” collateral includes all of the collateral eligible in the Fed’s open market operations, that is, Treasury securities, agency debt

securities, and agency MBS. "Schedule 2" collateral includes Schedule 1 collateral plus other investment grade debt securities.[6]

Auctions are typically held at 2 p.m. eastern time and are open for 30 minutes. Dealers may submit up to two bids. The minimum bid is $10 million, each bid can be for no more than 20 percent of the offering amount, and each dealer can be awarded no more than 20 percent of the offering amount. The auctions are single-priced, so that accepted dealer bids are awarded at the same rate, which is the lowest rate at which bids are accepted (also called the stop-out rate). The minimum fee for Schedule 1 and Schedule 2 auctions is 10 and 25 basis points (per annum), respectively.

The bid rate that a dealer submits represents the rate that it is willing to pay in order to borrow a basket of Treasury general collateral against other pledged collateral. The bid rate may therefore be considered as roughly equivalent to the spread between the financing rate for the pledged collateral and the Treasury general collateral financing rate over the term of a loan. It follows that dealers should have an incentive to participate in the program when the spread is greater than the program's minimum fee, but that dealers should rely solely on the private market when the spread is less than the minimum fee.

Shortly after the auction close, the Fed informs dealers of their firm's awards and posts summary auction results to the New York Fed's website. Loans settle on the business day following auction. Treasury collateral is allocated to dealers on a pro rata basis, so that a dealer awarded 10% of the offering amount receives a 10% share of each Treasury security

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

offered. The Fed reserves the right to substitute lent general collateral each day so as to avoid providing collateral that may trade with scarcity value in the repo market.[7]

To further mitigate credit risk, the Fed imposes a haircut on the collateral pledged by dealers, so that dealers must pledge collateral with a market value greater than the market value of the Treasury securities being borrowed. Moreover, dealers must ensure that the market value of their collateral remains sufficient on a daily basis. Dealers may therefore need to make collateral substitutions over the term of a loan if the pledged collateral deteriorates in value or falls out of the eligible collateral pool.

D. TSLF Options Program

On July 30, 2008, the Fed announced the introduction of auctions of options on $50 billion of draws on the TSLF. That is, the options allow dealers to borrow Treasury securities from the TSLF. The Fed said such options would be offered for exercise "in advance of periods that are typically characterized by elevated stress in financial markets, such as quarter ends."[8] Draws on the TSLF through exercise of these options can be collateralized by the full range of Schedule 2 collateral.

3. Hypotheses

Our analysis of the TSLF focuses on repo rates and spreads for which data are publicly available. Anecdotal evidence supports the conjecture that the TSLF has been effective at narrowing spreads. Fleming, Hrung, and Keane (2009), for example, present

[7] The Fed selects securities for the collateral basket that are not trading with scarcity value (i.e., special) in the repo market, but repo market scarcity can change over the term of a loan, resulting in a substitution. One such substitution occurred April 9, 2008.
[8] See the Federal Reserve press release announcing the program, <http://www.federalreserve.gov/newsevents/press/monetary/20080730a.htm>.

evidence that the TSLF narrowed spreads, with the first operation, in particular, having an outsized effect. In this paper, we examine whether the continued experience of the TSLF, which permits an analysis with statistical rigor, reinforces that conclusion.

In particular, we examine how effective changes in collateral supply affect repo rates and spreads.[9] The underlying premise for the analysis is that an increase (decrease) in the amount of collateral available to the private market should decrease (increase) its marginal value, because of downward sloping demand, resulting in a higher (lower) repo rate. Repo rates for collateral not directly affected by the program should also increase or decrease, depending on the extent to which the collateral is a substitute for collateral that is directly affected.

The TSLF allows dealers to swap lower quality collateral for Treasury collateral. To the extent the TSLF is utilized, the supply of Treasury collateral available to the private market should increase, reducing the Treasury collateral's scarcity value and causing Treasury financing rates to rise. Our first hypothesis is thus:

> *H1: Changes in the amount outstanding under the TSLF are positively related to Treasury repo rates.*

Use of the TSLF should also reduce the supply of lower quality collateral available to the private market, increasing the collateral's scarcity value and causing financing rates on such collateral to decline. There are many types of lower quality collateral, however, and the collateral eligible for the TSLF varies by operation. The hypothesized effect on the two collateral types for which we have repo rates (agency debt and agency MBS) is either ambiguous or contingent on the collateral eligible to be pledged. Repo rates for agency

[9] Another hypothesis is that the TSLF narrows financing spreads by reducing uncertainty about dealers' ability to finance positions. If that were the case, one might expect the announcement of the introduction of the TSLF to narrow spreads, but the announcement had little discernible effect on repo rates or spreads.

debt, for example, could rise with use of the TSLF if agency debt collateral is a closer substitute for Treasury collateral than the lowest-quality collateral eligible for pledging.

That said, agency debt and agency MBS collateral are certainly closer substitutes than Treasury collateral for the lowest-quality collateral eligible for pledging. Therefore, even if agency repo rates rise with use of the TSLF, they should not rise as much as Treasury repo rates. It follows that use of the TSLF should cause agency and agency MBS repo spreads to narrow. Our second hypothesis is thus:

> *H2: Changes in the amount outstanding under the TSLF are negatively related to agency and agency MBS repo spreads to Treasury repo rates.*

In TSLF Schedule 1 operations, only agency debt and agency MBS collateral can be pledged as collateral.[10] Agency MBS collateral is considered less valuable, trading at a higher repo rate, so one would expect this collateral and not agency debt to be predominantly pledged in Schedule 1 operations. Participation in TSLF Schedule 1 operations should therefore decrease the supply of agency MBS collateral available to the private market, increasing its scarcity value and causing agency MBS repo rates to decline. (Following the discussion above, the effect on agency repo rates is ambiguous.) Our third hypothesis is thus:

> *H3: Changes in the amount outstanding under the TSLF due to Schedule 1 operations are negatively related to agency MBS repo rates.*

In TSLF Schedule 2 operations, collateral of lower quality than agency debt and agency MBS can be pledged. The effect of such operations on agency and agency MBS repo rates is ambiguous, following the discussion above. However, participation in TSLF Schedule 2 operations should have a more positive (less negative) effect on Treasury,

[10] Technically, Treasury debt can also pledged as collateral, but no dealer should ever find it economic to bid a fee to borrow generally Treasury collateral while pledging other Treasury securities as collateral.

agency, and agency MBS repo rates than Schedule 1 operations. Our fourth hypothesis is thus:

> *H4: Changes in the amount outstanding under the TSLF due to Schedule 2 operations are more positively (less negatively) related to Treasury, agency, and agency MBS repo rates than changes in the amount outstanding under the TSLF due to Schedule 1 operations.*

As discussed, the effects of both Schedule 1 and Schedule 2 TSLF operations on agency repo rates are ambiguous. This follows from agency debt collateral being considered of lower quality than Treasury collateral, but higher quality than agency MBS collateral. One prediction that follows from this relationship is that the effects of the TSLF on agency repo rates lie somewhere between the effects of the TSLF on Treasury repo rates and the effects on agency MBS repo rates. Our fifth hypothesis is thus:

> *H5: Changes in the amount outstanding under the TSLF have an effect on agency repo rates that is less positive than the effect on Treasury repo rates, but more positive than the effect on agency MBS repo rates.*

Our last hypothesis is that TSLF effects depend on market conditions and, in particular, on the level of repo rates relative to the fed funds rate. While repos are secured transactions, fed funds transactions are unsecured. It follows that the overnight Treasury repo rate is nearly always below the overnight fed funds rate and that the fed funds rate effectively puts a cap on the repo rate. When the repo rate is close to the fed funds rate, there is little room for the repo rate to rise. In contrast, during periods of stress, when the repo rate is far below the fed funds rate, there is ample room for the spread to narrow. Our sixth hypothesis is thus:

> *H6: The effects of changes in the amount outstanding under the TSLF on repo rates and spreads increase with the spread between the fed funds rate and the Treasury general collateral repo rate.*

4. Data

A. TSLF Operations

Data on TSLF operations comes from the Federal Reserve Bank of New York's website (<http://www.newyorkfed.org/markets/tslf/termseclending_Historical.cfm>). Our analysis is based on the first 37 operations, running from March 27 to October 30, 2008. Operations occur weekly at the beginning of our sample, with the collateral eligible to be pledged alternating between Schedule 1 and Schedule 2. Starting September 17 (two days after Lehman Brothers filed for bankruptcy), the frequency of Schedule 2 auctions is increased to weekly (with Schedule 1 auctions still held every two weeks).

Descriptive statistics for the TSLF auctions are reported in Table 1 and data for individual auctions are reported in the Appendix. Offered amounts for every Schedule 1 operation are $25 billion, while amounts for Schedule 2 operations range from $35 billion to $75 billion. Bid-to-cover ratios are often below one, with 5 of 16 Schedule 1 operations undersubscribed and 12 of 21 Schedule 2 operations undersubscribed. Stop-out rates average 25 basis points for Schedule 1 operations and 88 basis points for Schedule 2 operations, but are often at the minimum fees of 10 and 25 basis points, respectively.[11]

The high level of dealer participation at many operations is itself a positive sign. An ongoing obstacle to the effectiveness of the Fed's discount window is that banks have been reluctant to use it because of a perceived stigma. The stigma arises from banks' concerns that adverse inferences will be drawn about their creditworthiness if their borrowing were to become known. The TSLF may have overcome this stigma because of

[11] For Schedule 2 operations there is a one-to-one relationship between undersubscribed auctions and stop-out rates at the minimum fee. In contrast, two Schedule 1 operations were fully subscribed with stop-out rates at the minimum fee and one operation was undersubscribed with a stop-out rate above the minimum fee.

its competitive auction format and expectation that a certain amount of securities would be made available.[12]

At the same time, undersubscriptions at other TSLF auctions may be indicative of improved market functioning and of the Fed having set the minimum fees at appropriate levels. The Fed set the minimum fees to be somewhat higher than the cost of borrowing Treasury securities against program-eligible collateral in the private market under normal circumstances. As a result, dealers should only find it attractive to use the facility when the market is impaired. The facility is thus designed to be self-liquidating as market conditions improve.[13]

We also use data on TSLF options provided on the New York Fed's website (<http://www.newyorkfed.org/markets/top/topseclending.cfm>). In our sample period, two auctions are held, on August 27, 2008 and September 10, 2008, each allowing for $25 billion in draws on the TSLF for one week over the September 30, 2008 quarter-end. Both auctions are fully subscribed. Options are ultimately exercised for $47.2 billion of borrowing.

B. Repo Rate Data

Our primary source for repo rate data is the Federal Reserve Bank of New York'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 each dealer on the average

[12] The Term Auction Facility is also thought to have largely overcome the stigma problem for this reason (see, for example, Chairman Bernanke's May 13, 2008 speech on "Liquidity Provision by the Federal Reserve," <http://www.federalreserve.gov/newsevents/speech/bernanke20080513.htm>). While the stigma has historically referred to banks' hesitance to borrow from the discount window, press reports suggest that a similar stigma may explain primary dealers' lack of borrowing from the Primary Dealer Credit Facility ("Fed Watch: In Vexing Trend: Primary Dealers Shun Fed Liquidity," Dow Jones Newswires, September 12, 2008).

[13] Governor Kohn discussed this issue in a May 29 speech on "Money Markets and Financial Stability," <http://www.federalreserve.gov/newsevents/speech/kohn20080529a.htm>.

overnight general collateral repo rate at which it has financed its positions in Treasury securities, agency debt securities, and agency MBS, as well as the quantity of securities financed. An overall weighted average is then calculated for each collateral type. These data are used to help gauge funding market conditions and to set spreads for the Fed's open market operations.

A secondary source for repo rate data is Bloomberg. Bloomberg reports closing general collateral repo rates for Treasury securities, agency debt securities, and agency MBS for maturities of one day, one week, two weeks, three weeks, one month, two months, and three months. The source of the data is ICAP North America, a large interdealer broker. Longstaff (2000) uses this data in his analysis of the term structure of repo rates.

C. Other Data

For robustness tests, we use the option-adjusted spread on the Merrill Lynch Global Financial Bond index as a control for credit conditions in the financial sector. We also use Treasury security issuance and redemption data from the Daily Treasury Statement in such tests to control for another important source of Treasury security supply and to provide an additional test of how underlying security supply affects repo rates.

5. Empirical Results

A. TSLF Effects on Repo Rates and Spreads

We test our first two hypotheses by regressing changes in repo rates and spreads on changes in the amount outstanding under the TSLF. In particular, we look at changes on the settlement day of the TSLF operations. We focus on settlement days because overnight repo

rates are affected by the supply of securities in the market on that day.[14] Changes in the amount outstanding under the TSLF are then calculated as the amount awarded in the TSLF operation settling that day less any amounts maturing that day from previous TSLF operations. Amounts outstanding include amounts exercised through the TSLF Options Program.

To better ascertain the effects of the TSLF, we implement two controls in our analyses. First, we assess changes in repo rates relative to changes in the fed funds target rate, which tend to be immediately transmitted to other overnight rates. The results are virtually the same without this differencing. Also, all of our models contain dummy variables for the last and first trading days of the calendar quarter, on which repo spreads typically widen and narrow, respectively. Again, the results are virtually the same without these variables, although the explanatory power of the models is lower.

Our initial results, presented in Table 2, support our first two hypotheses. The first column of results shows that changes in the amount outstanding under the TSLF are positively related to the overnight Treasury repo rate, supporting the first hypothesis. The coefficient of 0.97 suggests that each additional billon dollars in Treasury securities lent through the program is associated with an increase in the overnight Treasury repo rate of one basis point. The control variables are also highly significant, indicating that Treasury repo rates tend to decline on the last day of the quarter and rise on the following day.

[14] The announcement of an upcoming TSLF auction, even if it were a surprise, would not necessarily affect overnight repo rates that day, two days before the supply of securities in the market changes. Moreover, as mentioned, the announcement of the TSLF program itself did not seem to have a discernible effect on repo rates or spreads. Similarly, a TSLF auction would not necessarily affect rates that day in a particular way, although rates could be affected one way or the other if an auction revealed information about demand. In any case, auctions are held late in the day, long after our repo rates are measured, so any effect of auctions on repo rates would be expected to enter rates the following day, which is also the settlement day.

The fourth and fifth columns of results show that changes in the amount outstanding under the TSLF are negative related to agency and agency MBS repo spreads, supporting the second hypothesis. The third and fourth columns of results show that agency and agency MBS repo rates are *positively* related to the amount outstanding under the TSLF, which explains why agency and agency MBS repo spreads narrow by less than Treasury repo rates rise. As discussed, we have no prediction for the effects on agency and agency MBS repo rates for the full sample, but note that agency and agency MBS repo rates were themselves unusually low just before the first operation.[15]

While the narrowing of repo spreads we observe comes from increases in the Treasury repo rate and not decreases in repo rates on lower quality collateral, it is worth noting that the increase in Treasury repo rates is important in and of itself. An unusually low Treasury general collateral repo rate puts downward pressure on repo rates for individual Treasury securities, increasing the likelihood of settlement problems (see Fleming and Garbade (2004, 2005)). Concern that settlement fails might impair the ability of the Fed to effectively implement monetary policy provided the impetus for the original securities lending program in 1969 (Fleming and Garbade (2007)).

B. Schedule 1 vs. Schedule 2 Effects

We test our third and fourth hypotheses by regressing changes in repo rates and spreads on changes in the amount outstanding from TSLF Schedule 1 and Schedule 2 operations separately. Options program draws on the TSLF are against Schedule 2

[15] Overnight repo rates for Treasury, agency, and agency MBS collateral are usually close to (i.e., within 10 basis points of) the fed funds rate, but were roughly 150, 90, and 30 basis points (respectively) less than the fed funds target rate right before the first operation.

collateral, so amounts outstanding under the option program are included with Schedule 2 amounts.

The results in Table 3 provide little evidence to support our third hypothesis. We hypothesized a negative Schedule 1 coefficient for the agency MBS repo rate in the third column of results. The coefficient is in fact negative, but insignificantly so. Moreover, the Schedule 1 coefficient for the Treasury repo rate, while positive, is insignificantly different from zero. Overall, Schedule 1 operations have little discernible effect on repo rates or spreads.

In contrast, the results in Table 3 provide strong support for our fourth hypothesis. That is, Schedule 2 coefficients are larger than Schedule 1 coefficients for the Treasury repo rate, agency repo rate, and agency MBS repo rate, as shown in the first three columns of results. Wald tests indicate that the Schedule 1 and Schedule 2 coefficients are significantly different from one another at the 5% level in all three rate regressions. More generally, the results show that all of the effects of the TSLF seem to be coming from the Schedule 2 operations. The findings suggest that agency debt and agency MBS collateral may be considered substitutes for Treasury collateral to a large degree, whereas the lower quality collateral that can be pledged at Schedule 2 operations is not.

Additional results, presented in Table 4, suggest that the effects of the TSLF are concentrated around times that the settling TSLF operation is fully subscribed as opposed to undersubscribed. The results here are not as strong statistically, however, with Wald tests only indicating a statistical difference between subscribed and undersubscribed operations in the case of the Treasury repo rate, and there only at the 10% level. Moreover, we have no

formal hypothesis here of differential effects. The fully subscribed operations may be indicative of greater demand, which in turn may be correlated with TSLF effects.

Almost all of the paper's results, including those in Tables 2, 3, and 4, support our fifth hypothesis. That is, changes in the amount outstanding under the TSLF have an effect on agency repo rates that is less positive than the effect on Treasury repo rates, but more positive than the effect on agency MBS repo rates. These findings are consistent with the notion that agency debt collateral is of lower credit quality than Treasury collateral, but higher credit quality than agency MBS collateral.

C. Conditioning on Level of Repo Rates

We test our sixth and last hypothesis by adding a term to our simple regression model in which the amount outstanding under the TSLF is interacted with the spread between the fed funds rate and the Treasury repo rate. The spread is measured as of the day preceding settlement, to capture conditions before the TSLF has an effect, and is calculated as the fed funds target rate less the overnight Treasury repo rate.

Our results, presented in Table 5, support our hypothesis. The interaction term is significant in three of the models. The coefficient of 0.82 in the Treasury repo rate model, for example, means that each additional billion dollars in Treasury securities lent through the program is associated with an increase in the overnight Treasury repo rate of four-fifths of a basis point when the spread between the fed funds rate and the repo rate is 1%. The effect is commensurately smaller (larger) when the spread is narrower (wider). In contrast, changes in the amount outstanding by itself are not significant in any model (with multicollinearity explaining why neither the amount outstanding nor the interaction term is significant in two models).

D. Robustness Tests

We first estimate our basic set of models on the two halves of our sample period. The results, presented in Table 6, suggest our findings are robust. Changes in the amount outstanding under the TSLF have reasonably similar effects on repo rates and spreads in the two sub-periods. The coefficients are generally somewhat larger and more significant in the first sub-period, with the TSLF's effects on spreads, in particular, insignificant in the second sub-period.

We next add two control variables to our basic set of models. One control variable measures changes in the quantity of Treasury securities outstanding, calculated as Treasury issuance less Treasury redemptions. Consistent with the TSLF amounts, our Treasury supply variable is measured as of the actual issuance and maturity days (as opposed to announcement or auction days in the case of the new supply). The Treasury supply variable serves two purposes. One is to control for other variables that affect Treasury repo rates and repo spreads to Treasury repo, to ensure that the TSLF findings are robust. A second purpose is to provide an alternative test of Treasury supply effects on repo rates and spreads, as a robustness check of the more general hypothesis that Treasury security supply affects repo rates and spreads.

Our other control variable measures changes in the option-adjusted spread on the Merrill Lynch Global Financial Bond index. The index is intended to gauge credit conditions in the financial sector. Such conditions are likely related to repo rates and spreads. At the same time, the index is general enough that it is probably little affected by a facility such as the TSLF that is narrowly targeted to conditions in the repo market. To the extent changes in the amount outstanding under the TSLF do affect the corporate spread,

measured effects of the TSLF on repo rates and spreads are likely biased toward zero in models that include the corporate spread.

The results, presented in Table 7, suggest that the basic relationship between the amounts outstanding under the TSLF and repo rates and spreads is robust. The TSLF coefficients are similar in magnitude and statistical significance as in Table 2, although the spread coefficients are somewhat smaller in magnitude and less significant. The Treasury supply coefficient is significant and of the expected sign, indicating that increases in Treasury supply tend to increase Treasury repo rates and decrease agency and agency MBS repo spreads. The corporate bond spread coefficient is also significant. Consistent with a flight-to-quality story, increases in the spread are associated with decreases in the Treasury repo rate and increases in agency and agency MBS repo spreads.

We also assess the effects of the TSLF on monthly repo rates and spreads as opposed to overnight rates and spreads. One month maturities might seem more appropriate given that the TSLF lends Treasury collateral against other collateral for terms of 28 days. The term market is less liquid, however, making it harder to gauge any effects precisely. Moreover, the effects of the TSLF on term rates are harder to measure because term rates depend on expectations about future TSLF operations. In any case, TSLF coefficients in the simple set of models are of similar statistical significance when looking at monthly rates and spreads, albeit of smaller magnitude, as would be expected (results not reported to save space).

A final robustness test we employ is to utilize repo rate data from Bloomberg as opposed to repo rate data from the Fed. The Bloomberg data probably offer a less reliable read of market conditions because they provide once-a-day snapshots of rates from a single

broker, as opposed to weighted average rates covering much of the market. Moreover, the Bloomberg data are sometimes missing altogether, particularly for agency MBS repo towards the end of the sample period. On the other hand, the Bloomberg data are measured later in the day, as of the market close, and may therefore capture different information than the Fed data. In the simple set of models, measured effects of the TSLF using the Bloomberg data are stronger for the Treasury and agency repo rates and agency MBS spread, but weaker for the agency MBS repo rate and agency spread (results not reported to save space).

6. Conclusion

We find evidence that the Term Securities Lending Facility is effective at narrowing repo spreads between Treasury collateral and lower quality collateral. We further find that the observed narrowing emanates from an increase in Treasury repo rates as opposed to a decrease in repo rates on lower quality collateral. Further tests are consistent with, if not supportive of, our additional hypotheses regarding the differential effects of the different operation types and of how the effects are related to market conditions. Additional tests suggest that our findings are robust to splitting the sample and to the inclusion of additional variables which influence repo rates and spreads.

Our findings of significant effects from a central bank liquidity facility differ somewhat from those of prior studies. We think our results are particularly strong because the TSLF provides for a strong test of supply effects with minimal difficulties arising from endogeneity issues. The TSLF does in fact affect the composition of fixed income collateral in the market, and overnight repo rates and spreads are highly sensitive to supply changes on

TSLF settlement days, but are not substantively affected by expectations of future changes in supply. Our evidence on supply effects is consistent with extant evidence in the fixed income markets, where several studies find Treasury supply to be relevant to outright prices and where other studies relate the effective supply of particular securities to the cost of financing those securities.

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Table 1 – TSLF Auction Descriptive Statistics

	All (n=37)	Schedule 1 (n=16)	Schedule 2 (n=21)
Offered Amount	41.0 (25-75)	25 (25-25)	53.2 (35-75)
Bid-to-Cover	1.19 (0.29-2.07)	1.37 (0.29-2.07)	1.04 (0.49-2.04)
Accepted Amount	31.6 (7.2-75)	22.5 (7.2-25)	38.6 (26.1-75)
Stop-Out Rate	60.6 (10-322)	24.5 (10-151)	88.1 (25-322)

The table reports descriptive statistics for TSLF auctions (excluding TSLF Options Program auctions) between March 27, 2008 and October 30, 2008. Averages are reported with the minimum-maximum range in parentheses. Amounts are in billions of dollars, par value, and rates are in basis points.

Table 2 – TSLF Effects on Repo Rates and Spreads

	Dependent Variable: Change in Overnight Rate/Spread				
Independent Variable	Treasury Rate	Agency Rate	Agency MBS Rate	Agency Spread	Agency MBS Spread
Constant	-1.03	-1.06	-0.90	-0.03	0.13
	(1.94)	(1.54)	(1.54)	(1.85)	(2.02)
TSLF	0.97***	0.66***	0.43***	-0.31*	-0.54***
	(0.19)	(0.15)	(0.15)	(0.18)	(0.20)
Quarter End	-54.44***	8.64	23.28**	63.08***	77.71***
	(14.42)	(11.47)	(11.46)	(13.77)	(14.99)
Quarter Beginning	58.81***	-21.75*	-31.79***	-80.55***	-90.60***
	(14.42)	(11.47)	(11.46)	(13.77)	(14.99)
Adjusted R^2	24.1%	10.6%	9.1%	24.8%	28.8%

The table reports the results of least squares regressions of daily changes in overnight general collateral repo rates (relative to changes in the fed funds target rate) and repo spreads (to Treasury) on the quantity of Treasury securities provided to the market via the TSLF and on dummy variables for the first and last days of the calendar quarter. Repo rates and spreads are in basis points and security quantities are in billions of dollars, par value, and measured on the settlement date. The period of analysis is March 3, 2008 to October 31, 2008. Coefficients are reported with standard errors in parentheses. One, two, and three asterisks indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3 – TSLF Schedule 1 vs. Schedule 2 Effects

	Dependent Variable: Change in Overnight Rate/Spread				
Independent Variable	Treasury Rate	Agency Rate	Agency MBS Rate	Agency Spread	Agency MBS Spread
Constant	-0.86	-0.93	-0.81	-0.08	0.05
	(1.93)	(1.54)	(1.54)	(1.86)	(2.02)
Schedule 1	0.02	-0.04	-0.06	-0.06	-0.08
	(0.54)	(0.43)	(0.43)	(0.52)	(0.57)
Schedule 2	1.10***	0.76***	0.50***	-0.34*	-0.61***
	(0.20)	(0.16)	(0.16)	(0.20)	(0.21)
Quarter End	-54.60***	8.52	23.19**	63.12***	77.80***
	(14.31)	(11.40)	(11.45)	(13.80)	(15.00)
Quarter Beginning	58.64***	-21.87*	-31.87***	-80.51***	-90.52***
	(14.31)	(11.40)	(11.45)	(13.80)	(15.00)
Adjusted R^2	25.2%	11.6%	9.3%	24.4%	28.7%

The table reports the results of least squares regressions of daily changes in overnight general collateral repo rates (relative to changes in the fed funds target rate) and repo spreads (to Treasury) on the quantity of Treasury securities provided to the market via TSLF Schedule 1 and Schedule 2 operations and on dummy variables for the first and last days of the calendar quarter. Repo rates and spreads are in basis points and security quantities are in billions of dollars, par value, and measured on the settlement date. The period of analysis is March 3, 2008 to October 31, 2008. Coefficients are reported with standard errors in parentheses. One, two, and three asterisks indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4 – TSLF Fully Subscribed vs. Undersubscribed Effects

	Dependent Variable: Change in Overnight Rate/Spread				
Independent Variable	Treasury Rate	Agency Rate	Agency MBS Rate	Agency Spread	Agency MBS Spread
Constant	-1.46	-1.35	-1.08	0.11	0.39
	(1.94)	(1.55)	(1.55)	(1.87)	(2.03)
Fully Subscribed	1.13***	0.77***	0.50***	-0.36*	-0.63***
	(0.21)	(0.17)	(0.17)	(0.20)	(0.22)
Under Subscribed	0.07	0.06	0.05	-0.01	-0.02
	(0.50)	(0.40)	(0.40)	(0.48)	(0.52)
Quarter End	-54.00***	8.93	23.46**	62.93***	77.46***
	(14.30)	(11.41)	(11.46)	(13.80)	(14.98)
Quarter Beginning	59.25***	-21.45*	-31.60***	-80.70***	-90.85***
	(14.30)	(11.41)	(11.46)	(13.80)	(14.98)
Adjusted R^2	25.3%	11.5%	9.1%	24.5%	28.9%

The table reports the results of least squares regressions of daily changes in overnight general collateral repo rates (relative to changes in the fed funds target rate) and repo spreads (to Treasury) on the quantity of Treasury securities provided to the market via fully subscribed and under subscribed TSLF operations and on dummy variables for the first and last days of the calendar quarter. Repo rates and spreads are in basis points and security quantities are in billions of dollars, par value, and measured on the settlement date. The period of analysis is March 3, 2008 to October 31, 2008. Coefficients are reported with standard errors in parentheses. One, two, and three asterisks indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5 – TSLF Effects Conditional on Market Conditions

	Dependent Variable: Change in Overnight Rate/Spread				
Independent Variable	Treasury Rate	Agency Rate	Agency MBS Rate	Agency Spread	Agency MBS Spread
Constant	-1.19	-1.16	-0.95	0.03	0.24
	(1.90)	(1.53)	(1.54)	(1.85)	(2.00)
TSLF	0.04	0.10	0.12	0.06	0.08
	(0.37)	(0.29)	(0.30)	(0.36)	(0.39)
TSLF * Fed Funds Spread	0.82***	0.49**	0.27	-0.33	-0.55*
	(0.28)	(0.22)	(0.22)	(0.27)	(0.29)
Quarter End	-54.27***	8.74	23.33**	63.01***	77.60***
	(15.55)	(11.33)	(11.45)	(13.75)	(14.87)
Quarter Beginning	58.98***	-21.65*	-31.73***	-80.62***	-90.71***
	(15.55)	(11.33)	(11.45)	(13.75)	(14.87)
Adjusted R^2	27.5%	12.6%	9.3%	25.0%	29.9%

The table reports the results of least squares regressions of daily changes in overnight general collateral repo rates (relative to changes in the fed funds target rate) and repo spreads (to Treasury) on the quantity of Treasury securities provided to the market via the TSLF, on the quantity provided via the TSLF interacted with the previous day's spread between the fed funds target rate and the Treasury repo rate, and on dummy variables for the first and last days of the calendar quarter. Repo rates and spreads are in basis points and security quantities are in billions of dollars, par value, and measured on the settlement date. The period of analysis is March 3, 2008 to October 31, 2008. Coefficients are reported with standard errors in parentheses. One, two, and three asterisks indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6 – TSLF Split Sample Results

Panel A: March 3, 2008 to June 30, 2008					
	Dependent Variable: Change in Overnight Rate/Spread				
Independent Variable	Treasury Rate	Agency Rate	Agency MBS Rate	Agency Spread	Agency MBS Spread
Constant	-0.16	-1.03	-0.62	-0.87	-0.46
	(2.69)	(1.96)	(1.57)	(2.44)	(2.42)
TSLF	1.16***	0.85***	0.39***	-0.31	-0.77***
	(0.25)	(0.18)	(0.15)	(0.23)	(0.23)
Quarter End	-55.33***	9.49	24.67**	64.83***	80.00***
	(17.20)	(12.54)	(10.05)	(15.59)	(15.49)
Quarter Beginning	92.99***	25.00	10.97	-67.99***	-82.02***
	(24.18)	(17.63)	(14.12)	(21.91)	(21.77)
Adjusted R^2	34.6%	19.9%	11.2%	24.1%	37.7%

Panel B: July 1, 2008 to October 31, 2008					
	Dependent Variable: Change in Overnight Rate/Spread				
Independent Variable	Treasury Rate	Agency Rate	Agency MBS Rate	Agency Spread	Agency MBS Spread
Constant	-1.82	-1.05	-1.17	0.77	0.66
	(2.79)	(2.29)	(2.59)	(2.83)	(3.23)
TSLF	0.74**	0.43*	0.47*	-0.30	-0.27
	(0.29)	(0.24)	(0.27)	(0.30)	(0.34)
Quarter End	-53.57**	6.88	20.22	60.45**	73.79**
	(25.50)	(20.99)	(23.70)	(25.91)	(29.60)
Quarter Beginning	42.09**	-45.14***	-53.03***	-87.23***	-95.12***
	(18.14)	(14.93)	(16.86)	(18.43)	(21.06)
Adjusted R^2	13.3%	10.1%	11.2%	23.3%	22.2%

The table reports the results of least squares regressions of daily changes in overnight general collateral repo rates (relative to changes in the fed funds target rate) and repo spreads (to Treasury) on the quantity of Treasury securities provided to the market via the TSLF and on dummy variables for the first and last days of the calendar quarter. Repo rates and spreads are in basis points and security quantities are in billions of dollars, par value, and measured on the settlement date. Panel A reports results for the March 3, 2008 to June 30, 2008 period and Panel B reports results for the July 1 to October 31, 2008 period. Coefficients are reported with standard errors in parentheses. One, two, and three asterisks indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7 – TSLF Effects with Additional Control Variables

Independent Variable	Dependent Variable: Change in Overnight Rate/Spread				
	Treasury Rate	Agency Rate	Agency MBS Rate	Agency Spread	Agency MBS Spread
Constant	-0.51	-0.86	-1.18	-0.35	-0.66
	(1.93)	(1.83)	(1.65)	(1.79)	(1.91)
TSLF	0.90***	0.67***	0.45***	-0.22	-0.45**
	(0.18)	(0.15)	(0.15)	(0.17)	(0.18)
Treasury Issuance /Redemptions	0.29***	-0.05	-0.06	-0.34***	-0.36***
	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)
Corporate Bond Spread	-1.09***	0.04	0.32	1.13***	1.42***
	(0.25)	(0.21)	(0.21)	(0.23)	(0.25)
Quarter End	-66.30***	10.12	26.18**	76.42***	92.47***
	(13.57)	(11.73)	(11.64)	(12.61)	(13.45)
Quarter Beginning	53.17***	-20.80*	-30.56***	-76.42***	-83.73***
	(13.44)	(11.61)	(11.52)	(12.48)	(13.32)
Adjusted R^2	35.1%	9.7%	9.6%	39.2%	44.7%

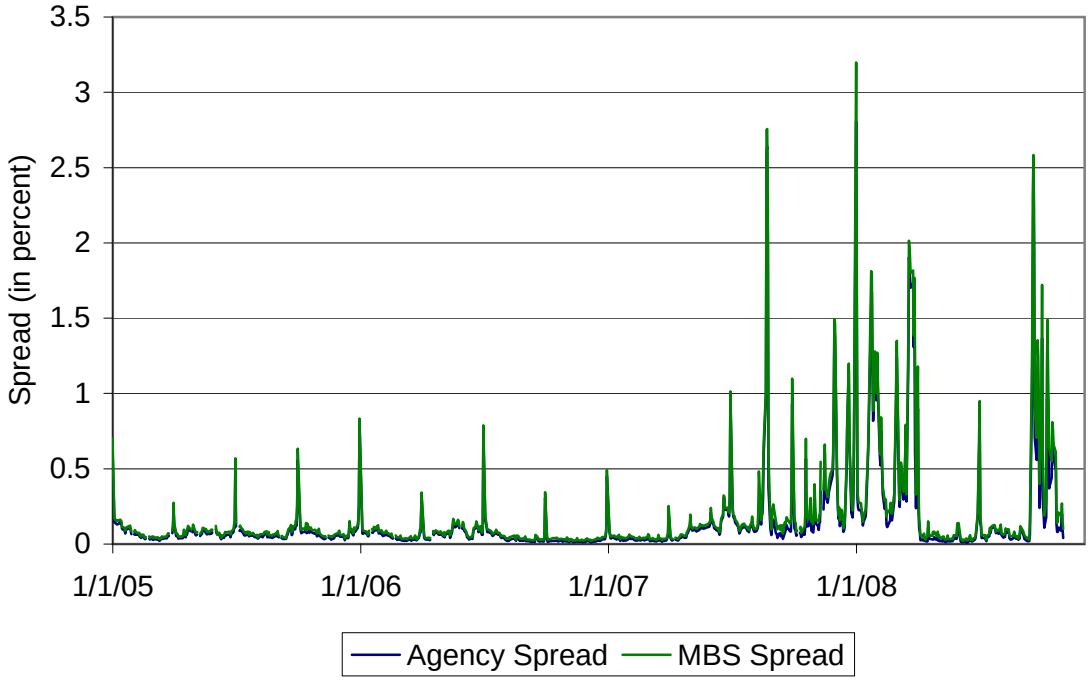
The table reports the results of least squares regressions of daily changes in overnight general collateral repo rates (relative to changes in the fed funds target rate) and repo spreads (to Treasury) on the quantity of Treasury securities provided to the market via the TSLF and via Treasury issuance and redemptions, changes in the Merrill Lynch Global Financial Bond option-adjusted spread, and dummy variables for the first and last days of the calendar quarter. Repo rates and spreads are in basis points and security quantities are in billions of dollars, par value, and measured on the settlement date. The period of analysis is March 3, 2008 to October 31, 2008. Coefficients are reported with standard errors in parentheses. One, two, and three asterisks indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Appendix – TSLF Auction Results

Auction Date	Collateral Schedule	Term	Offered Amount	Submitted Amount	Accepted Amount	Bid-to-Cover	Stop-Out Rate
3/27/08	2	28	75	86.1	75	1.15	33
4/3/08	1	28	25	46.9	25	1.88	16
4/10/08	2	28	50	33.95	33.95	0.68	25
4/17/08	1	28	25	35.1	24.999	1.40	10
4/24/08	2	28	75	59.46	59.46	0.79	25
5/1/08	1	28	25	24.12	24.12	0.96	10
5/8/08	2	28	50	28.77	28.77	0.58	25
5/15/08	1	28	25	7.24	7.24	0.29	10
5/22/08	2	28	75	46.13	46.13	0.62	25
5/29/08	1	28	25	16.43	16.43	0.66	10
6/5/08	2	31	50	26.9	26.9	0.54	25
6/12/08	1	28	25	27.2	24.997	1.09	10
6/19/08	2	28	75	36.8	36.8	0.49	25
6/26/08	1	28	25	15.4	15.4	0.62	11
7/3/08	2	25	50	26.1	26.1	0.52	25
7/10/08	1	28	25	21.3	21.3	0.85	10
7/17/08	2	28	75	51.75	50.75	0.69	25
7/24/08	1	28	25	51.72	24.998	2.07	12
7/31/08	2	28	50	28.1	28.1	0.56	25
8/7/08	1	28	25	39.5	24.998	1.58	13
8/14/08	2	28	75	39.25	39.25	0.52	25
8/21/08	1	28	25	44.65	25	1.79	14
8/28/08	2	28	50	26.65	26.65	0.53	25
9/4/08	1	28	25	45	24.999	1.80	15
9/11/08	2	28	75	40.85	40.85	0.54	25
9/17/08	2	14	35	64.35	35	1.84	250
9/17/08	2	28	35	71.25	34.998	2.04	300
9/18/08	1	28	25	49.6	24.999	1.98	151
9/25/08	2	27	37.5	61.2	37.5	1.63	102
10/1/08	2	28	35	66.65	34.999	1.90	151
10/2/08	1	28	25	49	25	1.96	42
10/9/08	2	27	37.5	62.78	37.5	1.67	305
10/15/08	2	28	37.5	73.65	37.5	1.96	322
10/16/08	1	28	25	44	25	1.76	46
10/22/08	2	28	37.5	47.25	37.5	1.26	50
10/29/08	2	29	37.5	53.1	37.5	1.42	38
10/30/08	1	28	25	30.8	24.999	1.23	12

The table reports data for TSLF auctions (excluding TSLF Options Program auctions) between March 27, 2008 and October 30, 2008. Terms are in days, amounts are in billions of dollars, par value, and rates are in basis points.

Figure 1 -- Repo Spreads



Note: The figure plots the overnight agency and agency MBS repo spreads to the overnight Treasury repo rate from January 3, 2005 to October 31, 2008.