Responses to the Financial Crisis, Treasury Debt, and the Impact on Short-Term Money Markets

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Abstract

U.S. fiscal and monetary authorities introduced several programs in response to the financial crisis. We examine responses involving Treasury debt supplies--the Term Securities Lending Facility (TSLF), Supplementary Financing Program, Treasury issuance, and open market operations. Considering policies simultaneously allows us to control for interactions. We find TSLF uniquely effective relative to other Treasury supplies. Further, we find that the effectiveness of the TSLF was due primarily to its introduction during the financial crisis. Our results show that the proper policy response to a financial crisis can involve options beyond an increase in the level of bank reserves.

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I. Introduction

In this study, we examine policy responses to the recent financial crisis involving Treasury debt and their impact on collateralized funding markets – an important channel for short term liquidity involving a wide range of financial institutions. The response to a disruption in the traditional-banking system typically follows the widely appreciated concept attributed to Walter Bagehot (1873): *to avert a panic, central banks should lend early and freely at high rates, to solvent firms, against good collateral.*[1] By 2007 however, short-term collateralized funding was central to the operations for many of the institutions which came under duress in the recent financial crisis. As these funding markets became impaired, a policy response based on a narrow interpretation of Bagehot's dictum would not have effectively relieved money market stresses. The impairment in collateralized funding markets called for more high quality collateral such as Treasury securities, not more cash or bank reserves. We focus on this aspect of the financial crisis in this study.

Since the fall of 2007, various programs together involving trillions of dollars have been introduced in the United States by both fiscal and monetary authorities in response to the financial crisis. In contrast to many other studies, we examine a number of policies instead of the impact of just a single policy response.

One such program, the Term Securities Lending Facility (TSLF) was introduced in March 2008, as money markets became severely impaired. The TSLF was specifically designed to address dislocations in money markets by exchanging Treasury securities for less liquid and lower quality collateral held by market participants. A second program, the Supplementary Financing Program (SFP), introduced in the fall of 2008, was designed to help the Federal

[1] As summarized by Tucker (2009).

Reserve manage bank reserves through the issuance of special Treasury debt, with proceeds held at the Federal Reserve Bank of New York (FRBNY). To the best of our knowledge, this study is the first to examine the SFP. A third, *fiscal*, policy change occurred as other Treasury debt issuance increased from late 2007 onward, as a result of increased expenditures and lower tax receipts. Other Treasury debt issuance was also directly tied to the financial crisis through programs such as the Troubled Asset Relief Program (TARP) and Treasury's Agency mortgage-backed security (MBS) purchase program. Finally, Open Market Operations (OMOs)—both temporary and permanent—which increase or decrease holdings of Treasury debt in the Federal Reserve's System Open Market Account (SOMA), also impacted market supplies of Treasury collateral. Over the course of the financial crisis, the Federal Reserve first sold Treasury holdings to maintain the size of its balance sheet to better manage the federal funds rate, and then later bought Treasury securities as part of its Large Scale Asset Purchase (LSAP) program. While the SFP, OMOs, and programs such as TARP were not aimed directly at dislocations in short-term money markets, they did impact the supply of Treasury securities available to be financed by money markets.

In general, collateralized rates, such as the over-night Treasury general collateral (GC) repurchase (repo) rate, should be similar to, but lower than uncollateralized rates, such as the federal (fed) funds rate. During the recent financial crisis, strains in collateralized funding markets were expressed through phenomenon such as collateralized rates exceeding uncollateralized rates, and sustained low relative rates for safer types of collateral, such as Treasury collateral.[2] In fact, as the financial crisis deepened and the quality of non-Treasury collateral came into question, the demand for Treasury collateral increased dramatically. As a

[2] Repo rates can be of various terms and are backed by various types of collateral. The over-night Treasury GC repo rate represents the rate on the shortest term for the safest and most liquid type of collateral. As such, this rate is a benchmark for other repo rates. Bartolini, Hilton, Sundaresan and Tonetti (2011) document that Treasury GC collateral forms the highest asset class in repo markets.

result of this outward shift in demand for high quality Treasury collateral, Treasury GC rates plunged relative to other collateralized and uncollateralized rates. While low interest rates are generally considered to be desirable, the low relative Treasury GC rates observed during the crisis were evidence of impaired market functioning for collateralized funds.

In the case of such impairment, increases in the supply of Treasury collateral can help alleviate strains in funding markets which result from increased demand for safe and liquid collateral. To the extent that market functioning improves as the supply of Treasury collateral increases, a simple supply-demand framework would predict that over-night Treasury repo rates should increase, and the spread to other collateralized and uncollateralized rates should narrow. Our results confirm this basic intuition.

Treasury collateral *can* be used as high quality repo collateral, however it does not necessarily follow that all increases in Treasury collateral *will* be utilized in funding markets. For example, investment guidelines may restrict the holdings of some investors to shorter term Treasury securities, suggesting changes in Treasury bill supply may have more of an impact on repo rates than changes in the supply of Treasury notes and bonds. Moreover, Treasury securities which are purchased by buy-and-hold investors are unlikely to be used as collateral in repo transactions. Our findings strongly support the idea that the propensity for any given Treasury obligation to support repo market activity differs systematically by source. Each program we study had different transmission channels, different initiation periods, and different patterns of changes in supply; herein each program's relative impact on the over-night Treasury GC repo market can be identified, with the largest impact coming from the TSLF. While other sources of Treasury collateral are found to impact repo rates on a smaller scale, our results nevertheless show that the proper policy response to a financial crisis may require options which do not involve an increase in bank reserves. In particular, the TSLF program was reserve-

neutral, and the increase in Treasury collateral from the SFP actually drained reserves from the banking system.

We also provide evidence that the impact of the TSLF was due primarily to its introduction and operation during the financial crisis. The TSLF was able to impact repo rates because it was introduced and in effect at a time when these rates were severely dislocated. By use of interactions we construct a synthetic counterfactual whereby we find the TSLF would have a much smaller effect on repo rates during a period of normal market functioning. Thus this paper contributes to the collective understanding of short-term money markets and hereby seeks to inform policy responses to future crises.

Moreover, our results suggest a modification of Bagehot's dictum.[3] During the financial crisis, securitized lending markets seized up due to a lack of high quality collateral instead of a lack of cash. As a result, the increase in the supply of high caliber collateral by the Federal Reserve, instead of an increase in bank reserves, helped facilitate the normalization of collateralized funding markets.

The remainder of this paper is structured as follows: Section 2 provides background on secured funding markets, the various policy responses to the financial crisis that involved Treasury debt and relevant literature; Section 3 describes our data and method; regression results are presented in Section 4; Section 5 concludes.

II. Background

Secured funding markets allow for collateralized borrowing by participants. In these markets, the most common type of transaction is a repurchase agreement, or repo. In a repo, a

[3] A specific addition might read as follows: *to avert a panic, central banks should lend early and freely at high rates, to solvent firms, against good collateral ‹and provide the additional liquidity in the form most appropriate to the situation—including exchange between forms of collateral›.*

sale of securities is combined with an agreement to repurchase the same securities at a later date, typically at a higher price The higher price represents an interest rate paid to the lender of the cash (buyer of the security), from the borrower of the cash (lender of the security). The lender of funds takes possession of the borrower's securities over the term of the loan and can resell them in the event of a borrower default. The borrower retains the spread between the interest rate on the security and the interest rate paid to the lender of cash. Gorton and Metrick (2011) give an excellent description of the repo securitization process.

Volume in the repo market is primarily then a function of demand for funds (borrowers interest in transactions) and their asset position (borrowers capacity to engage). The latter is subject to the market valuation of collateral and thus liquidity spirals are possible, as illustrated in Brunnermeier and Pedersen (2009) and more tangibly in the popular press by Lowenstein (2000). Tightening collateral requirements can cause rapid contractions in repo market activity for any particular firm, as well as generally. In fact this type of contraction occurred in the recent financial crisis, as shown in Adrian and Shin (2010).

Repo markets display segmentation as some contracts specify particular collateral to be used while others are "general"; for a general collateral (GC) repo, any given security within an asset category is acceptable as collateral by the lender. For example, a *Treasury GC repo* contains any Treasury security as collateral.[4] Overnight GC repo rates tend to track rates on uncollateralized overnight federal fund loans; the spread between the overnight GC repo rate and the fed funds target rate is typically less than 10 basis points (bps). This reflects the use of

[4] For a special collateral repo, the lender of funds seeks a specific security – identified by its particular CUSIP number.

GC repos as a mechanism for lending and borrowing money. In recent years, primary dealers have used repos to finance around $2-5 trillion in fixed-income securities.[5]

As a general rule, there should be a positive relationship between the supply of collateral and the interest rate that the borrower must pay to obtain funds (this is because scarce collateral is more valuable, and thus the borrower need pay less to borrow funds).[6] In fact, a body of literature on specialness and segmentation has evolved along with the repo market itself, both as narrowly defined with Duffie (1996), Jordan and Jordan (1997) and Fleming and Garbade (2004, 2007), and broadly to generic bond market demand and supply as seen in Greenwood and Vayanos (2008). Moreover, demand for particular bonds as collateral is a function of their liquidity, such that "on the run" issues (the latest issues) hold premium collateral status, as documented in Keane (1996) and Longstaff (2004).

In addition to studying the effects of Treasury collateral supply on collateralized funding rates, this study is related to other work on short-term money markets as well as to other studies examining the impact of various programs which were introduced over the course of 2007-2009 to address the multiple dislocations in financial markets. Within that literature, Gagnon et. al. (2010) and Neely (2010) addressed the Large Scale Asset Purchase program; Adrian, Kimbrough, and Marchioni (2010) considered the Commercial Paper Funding Facility; Goldberg, Kennedy, and Miu (2010) and Fleming and Klagge (2010) examined the Federal Reserve's foreign exchange swap lines; opposing views on the impact of the Term Auction Facility were offered by Taylor and Williams (2009) and McAndrews, Sarkar, and Wang (2008).[7] Freixas (2009) considered many of these newer liquidity injection mechanisms

[5] See http://www.newyorkfed.org/markets/primarydealers.html for information on primary dealer financing.

[6] See Fleming, Hrung, and Keane (2009, 2010b) for more details regarding secured financing markets.

[7] The Term Auction Facility is not investigated in this paper as this program was a cash-for-security exchange which did not directly impact the supply of Treasury collateral for repo transactions.

generally, noting limits to traditional monetary policy tools in the face on non-functioning interbank markets. Brunetti, Di Filippo and Harris (2011) considered European Central Bank (ECB) interventions over the financial crisis and found that those failing to target counterparty risk also failed to improve liquidity. That finding is important for this investigation for two reasons. First because those authors consider several types of ECB intervention in unison and second because one of the programs we investigate, the TSLF, in fact addressed counterparty risk. This is something that private parties were ill-equipped to do on their own. Those seeking funding needed to swap out-of-favor collateral for more acceptable forms in order to access short-term securitized debt markets. However the private market's ability to handle the swap process is quite limited in the midst of a collateral valuation crisis, because any private party agreeing to the collateral swap is exposed to the same counterparty risk the money market lender would have been, thus opportunities for distribution and dilution of risk are limited and a fundamental supply constraint is likely to persist.

Similar to Brunetti, Di Filippo and Harris, our study examines multiple policies. Here we consider both monetary and fiscal policy responses involving Treasury debt supplies simultaneously, so that we examine a number of policies instead of the impact of just a single policy response. Our results also highlight the need to carefully consider the interaction between various policies with the ability to impact areas beyond their intended targets.

A. The Term Securities Lending Facility (TSLF)

The TSLF was introduced on March 11, 2008 "to promote liquidity in the financing markets for Treasury and other collateral and thus to foster the functioning of financial markets

more generally."[8] As the financial crisis progressed, funding markets came under unprecedented stress; liquidity and counter-party concerns led many money market participants to seek out Treasury securities, and term funding became scarce. As a result, Treasury overnight GC was in high demand causing its rates to plunge and the spread between the fed funds target rate and Treasury GC repo rates widened to extraordinary levels as seen in Figure 1.[9] Other repo spreads such as the rate spread between Agency and Treasury GC collateral also widened markedly over this period.

‹Figure 1 here›

The TSLF addressed widening spreads by increasing the supply of Treasury collateral, which would be expected to increase Treasury GC rates and decrease repo rate spreads. Primary dealers with a trading relationship with the FRBNY were eligible to swap their holdings of less liquid collateral for Treasury securities held in the System Open Market Account (SOMA) for around 28 days.[10] The dealers bid a fee via a single-price auction to access the TSLF, with a minimum fee set by FRBNY.[11]

The TSLF was specifically designed to directly address money-market stresses.[12] Also worth noting, the program's policy design is uniquely elegant as it involves a security-for-security exchange and so does not expand the Federal Reserve's balance sheet and is therefore reserve-neutral. Thus there was no need to sterilize the impact of the TSLF and as a result the program was able to grow to a substantial size very quickly. As documented in Figure 2 within

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

[9] Longstaff (2004) documents pre-crisis flight to liquidity premiums in somewhat in line with the time *t* time *s* transmission mechanism suggested by Krishnamurthy (2010), though whether these were priced correctly at market circa 2002-2007 is debatable--especially in light of the TSLF as a policy innovation.

[10] Term lengths ranged from 14 to 35 days with most ranging between 27-29 days.

[11] For more on the TSLF, see Fleming, Hrung, and Keane (2009).

[12] The Federal Reserve also conducted 28-day single-tranche open market operations with primary dealers which involved Agency MBS collateral. These operations were also targeted at stresses in money markets. We do not examine this program as it did not involve Treasury collateral.

one month of the first TSLF auction, the facility reached $150 billion.[13] The facility briefly peaked to almost $250 billion in the fall of 2008 and wound down to zero by early August 2009 as rate spreads in the market contracted and rendered the facility uncompetitive (i.e. expensive relative to market alternatives). The TSLF officially expired on February 1, 2010.[14]

‹Figure 2 here›

B. Supplementary Financing Program (SFP)

Figure 2 also documents SFP balances over the policy period from 2008-2010. The U.S. Treasury announced the SFP on September 17, 2008, two days after the collapse of Lehman Brothers. In just over one month's time, the SFP reached its peak scale of $560 billion. The program was initiated at the request of the Federal Reserve with the aim of offsetting the balance sheet impact of the liquidity-providing efforts being implemented by the Federal Reserve during the financial crisis.[15] In other words, the program was designed to help the Federal Reserve drain bank reserves accumulating through liquidity facilities that were introduced at this point in the crisis. Because the level of bank reserves tends to impact the federal funds rate, such an offset to the increase in reserves was needed to help the Open Market Trading Desk meet the target for the federal funds rate set by the Federal Open Market Committee (FOMC).

The program consisted of the issuance of a series of Treasury bills, which were separate and distinct from regular Treasury debt issuance. SFP bills are essentially Cash Management

[13] Note that the maximum amount of Treasury collateral that can be supplied via TSLF is limited to Treasury holdings in the SOMA account. In early March 2008 the Federal Reserve held around $700 billion in Treasury securities. By the end of April 2008 the Federal Reserve held around $550 billion. We describe the evolution of the SOMA account over our sample period in greater detail below.

[14] The amounts presented and studied include amounts exercised in the TSLF Options Program. For more information on this program, see http://www.federalreserve.gov/newsevents/press/monetary/20080730a.htm .

[15] See http://www.ustreas.gov/press/releases/hp1144.htm and http://www.newyorkfed.org/markets/statement_091708.html.

Bills (CMBs). But whereas pricing of CMBs has tended to be punitive as they potentially drain liquid reserves from primary dealers as documented in Seligman (2006) and Simon (1991), SFP proceeds are more likely to be less disruptive because bank reserves accumulating at the time were in excess of what would normally have been productive. Further, an incidental by-product of the program was that it increased the amount of high-quality collateral available in the market, helping to alleviate the very same supply-side stresses in money markets that the TSLF was designed to address.

Another way in which SFP transactions differ from CMBs is in the utilization of funds from issuance. CMB proceeds, like regular Treasury issuance and certain classes of tax payments, are deposited in Treasury's General Account (TGA) at the FRBNY, the account that pays most Federal outlays; the TGA can be thought of as Treasury's "checking account." As the TGA is a liability item on the Federal Reserve's balance sheet, along with bank reserves, an increase in the TGA will decrease bank reserves, holding the size of the overall balance sheet constant. The proceeds from the "SFP bills" were placed in a separate account at the FRBNY, an account that does not accept tax receipts or pay outlays. However, similar to the TGA, an increase in the Supplementary Financing Account (SFA) decreases bank reserves.[16]

Comparing the TSLF and SFP in terms of sheer magnitude, note that the peak amount of Treasury collateral supplied by the SFP was more than double the peak amount supplied by the TSLF ($560 billion versus $223 billion). But while the SFP is a very effective method for quickly draining bank reserves, one drawback to the SFP as a policy instrument is that SFP bills count against the federal debt ceiling; as such, balances were soon reduced. The SFA decreased to $200 billion by early February 2009 and remained at that level into the third quarter of 2009. In mid-September 2009, again driven by concerns related to the debt ceiling, the Treasury announced a

[16] Amounts held in the TGA and SFA can be found on the Daily Treasury Statement and on the Federal Reserve's weekly H4.1 release.

further decrease in the SFP balance to $15 billion by the fourth quarter of 2009. The SFA briefly had a zero balance, but after the federal debt ceiling was increased in February 2010, the SFA again increased to $200 billion by mid-April 2010 and remained at the level through the end of our sample period. As well as documenting the two programs separately, Figure 2 displays the combined impact of both programs over the period of observation; at their peak in October 2008, the combined magnitude of the two programs exceeded $750 billion.

C. Treasury Issuance

As in previous recessions, federal tax revenue declines contributed to counter cyclical fiscal policy. US federal tax receipts began to fall in late 2007. This required increased debt issuance to cover budgetary short-falls. In addition federal outlays increased, widening the budget gap and necessitating a further increase in debt issuance. Beyond both of these traditional "automatic stabilizer" channels, increased outlays due to programs directly related to the financial crisis, such as the Troubled Asset Relief Program (TARP) and Treasury's Agency mortgage-backed security (MBS) purchase program, enhanced federal funding requirements. TARP expended around $380 billion (it has been repaid around $175 billion as of March 31, 2010), and Treasury's Agency MBS purchase program purchased a total of $221 billion from September 2008 through December 2009.[17] Figure 3 presents monthly federal receipts and outlays, as well as the quantity of marketable outstanding Treasury obligations (net of SFP) from January 2007 through April 2010.

‹Figure 3 here›

[17] Information on TARP and Treasury's Agency MBS purchase program can be found at http://www.financialstability.gov.

The U.S. Treasury responded to funding needs by increasing the number of different types of securities, as well as increasing the frequency of auctions. Table 1 compares 2009 and 2006 auction policy, documenting the addition of a 52-week bill and a 7-year note. Auction frequencies increased for the 3-year, 10-year, and 30-year issues.

‹Table 1 here›

Further, as highlighted in Figure 3, the level of outstanding marketable Treasury debt (excluding SFP) increased substantially over the course of 2008-2009. Note in the top panel of the figure that there are seasonal fluctuations in the level of outstanding Treasury debt, so that the level does not monotonically increase. For example, April tax season typically results in net pay-downs of Treasury debt, and a decrease in the level of outstanding Treasury securities.

D. Open Market Operations (OMO)

In this section we detail temporary and permanent Open Market Operations over the period of observation beginning first with temporary operations.

Temporary Open Market Operations

The top panel of Figure 4 details the magnitude and frequency of temporary operations impacting Treasury collateral.[18] Temporary OMOs are conducted by the Open Market Trading Desk of the FRBNY to adjust the aggregate supply of bank reserves to foster conditions in the market consistent with the FOMC's policy directive for the federal funds rate. These operations consist of short-term repurchase and reverse repurchase agreements which impact daily trading in the federal funds market. Note that an OMO that drains reserves will add OMO-eligible

[18] Excluded are operations involving Agency debt and MBS.

collateral (Treasury, Agency debt, and Agency MBS) to the market, and vice versa.[19] Upon maturity of the operation, the movement of collateral is reversed. The term of these operations typically ranges from overnight to 28 (business) days. For more on temporary OMOs, see Carpenter and Demiralp (2006), Hilton and Hrung (2010), and Friedman and Kuttner (2010).

As the top panel of Figure 4 highlights, the active daily management of bank reserves via temporary OMOs by the trading desk is concentrated prior to and through the initial phases of the crisis. By the end of 2008, when the FOMC adopted a target range of 0-25 bps for the fed funds rate instead of an explicit target rate, the trading desk stopped conducting temporary OMOs for the remainder of the sample period, aside from some small-scale operations at the end of 2009. More detailed information on the breakdown of Treasury collateral provided for OMOs (e.g., bills vs. notes and bonds) is not publicly available.

‹Figure 4 here›

Permanent Open Market Operations

The Federal Reserve's SOMA portfolio traditionally consists primarily of Treasury securities. These holdings tend to grow over time so as to roughly match growth in currency demand. A permanent OMO to purchase Treasury securities decreases the amount of Treasury collateral available for private parties to utilize in Treasury-securitized repo finance. Figure 4 shows that prior to the crisis in the fall of 2007, the Federal Reserve conducted a number of OMOs, of which the permanent OMOs were all confined to be purchases under $5 billion in size.

As the crisis intensified, the Federal Reserve's balance sheet began to take on riskier assets as emergency liquidity facilities were introduced. These assets collateralized the funds

[19] Operations during our sample period that drained reserves only involved Treasury collateral.

provided to financial institutions via the liquidity facilities. In an effort to maintain the size of its balance sheet, the Federal Reserve began to allow its Treasury holdings to mature and to sell its holdings. These sales increased the supply of Treasury collateral available to the public. As the bottom two panels of Figure 4 reveal, the Federal Reserve sold a greater amount of its Treasury bill holdings than coupon holdings. In the fall of 2008, the Federal Reserve no longer sought to maintain the size of its balance sheet and Treasury redemptions/sales were discontinued.

In March 2009, the FOMC announced that it would purchase $300 billion in longer-dated Treasury securities as part of its Large Scale Asset Purchase program (LSAP).[20] The purpose of these purchases was to "help improve conditions in private credit markets", not the repo market.[21] These purchases, which removed Treasury collateral from market, commenced later that month and were completed by the end of October 2009. By the end of the purchases, total SOMA Treasury holdings were similar to their pre-crisis levels, albeit with a different maturity composition weighted more toward coupon holdings (Figure 5).

Note that within our observation period, there are only seven operations involving bill sales so it may be difficult to identify the full relationship between repo rates and changes in bills availability due to SOMA sales. By contrast, changes in SOMA's Treasury coupon holdings exhibit fuller variation dynamics in that holdings were both purchased and sold over our sample period.

To summarize, Table 2 presents the various sources of Treasury collateral and their primary motivation. The third column presents the respective program's expected impact on

[20] See http://www.federalreserve.gov/newsevents/press/monetary/20090318a.htm for the announcement. The Federal Reserve also purchased $1.25 trillion in Agency MBS and around $172 billion in Agency debt.

[21] http://www.newyorkfed.org/markets/funding_archive/lsap.html. Gagnon et. al (2010) examine the impact of LSAPs on domestic interest rates, and Neely (2010) examines their impact on foreign interest rates and exchange rates.

the Fed funds target-GC rate spread relative to the TSLF. These will be discussed in the next section. Since all of the programs in Table 2 impacted the supply of Treasury collateral, the table highlights the need to carefully consider the impact of policies beyond their intended target. For example, the SFP was primarily intended to the help drain the level of bank reserves, while LSAP purchases helped lower longer-term U.S. interest rates. But while the SFP program reinforced the increases in Treasury collateral from TSLF, LSAP purchases of Treasury securities actually removed Treasury collateral.

‹Table 2 here›

III. Data and Methods

We analyze daily data from January 2007 through May 2010. This time frame extends from a period pre-crisis and through the period over which the several direct and indirect policies described in the last section manifest: the TSLF and LSAP program, the initiation of the SFP and the rapid expansion of outstanding publicly held Treasuries from below five trillion to close to eight trillion dollars. All these data are publicly available.

Our dependent variable is the change in the spread between the overnight Treasury GC repo rate and the fed funds rate target set by the FOMC ("the spread", or the "FF-Repo spread") as documented in Figure 1. Examining this spread rather than the change in GC repo rates accounts for the role the fed funds rate typically serves--as a ceiling for repo rates. This is because fed funds transactions are uncollateralized, and collateralized borrowing is typically less expensive. So as the fed funds target changes, repo rates also change irrespective of the level

of relevant collateral. For the sub-period where the fed funds target was the range of 0-25 bps (since mid-December 2008), we set the target rate to 25 bps.[22]

Data for GC rates come from Bloomberg. As noted in Fleming, Hrung, and Keane (2010a, b), overnight rates are impacted by the amount of collateral available on a given day; meaning expectations and other potential sources of endogeneity are less of a concern.[23]

The change in the rate spread is related to changes in Treasury collateral, broken into TSLF, SFP, Treasury bills, and Treasury coupon securities (notes and bonds), temporary OMOs, SOMA bills, and SOMA coupon securities (notes and bonds) categories.[24] While all Treasury securities are eligible to serve as collateral in a Treasury GC repo, the different types of securities could have different impacts on GC rates. For example, the TSLF was targeted at and introduced during a time of great stress in funding markets when rate spreads were much wider than typical. As a result, Treasury securities lent out via the TSLF were likely to have been used as collateral in repo transactions. Also, there was more scope for a large TSLF impact than if rate spreads were at typical levels (less than 10 bps). However, the SFP was initiated in the fall of 2008, when funding markets were facing unprecedented stress following the bankruptcy of Lehman Brothers and, as noted above, the SFP at its peak actually provided more than twice the amount of Treasury collateral as the TSLF at its peak. So the SFP may impact FF-Repo spreads in ways that are similar to the TSLF even though it was not directed at stresses in funding markets.

[22] In an alternate specification not reported here for the sake of brevity, we employ a midpoint of 12.5 bps as the target rate in the target-range period from December 16, 2008 – May 28, 2010. Results are essentially equivalent.

[23] For example, results of TSLF auctions were released a day or two before settlement, so that amounts settling were known in advance. The overnight GC rate is only impacted by the TSLF settlement, not the announcement of the auction results.

[24] The TSLF auctions alternated in terms of the types of collateral which could be exchanged for Treasury securities. Previous studies (Fleming, Hrung, and Keane (2010a,b)) have examined the two types, or "schedules" separately. However, we are concerned only with the amount of Treasury collateral supplied, not the type of collateral withdrawn from the market, so we do not distinguish between Treasury collateral provided by the different auctions.

Also worth considering, bills (including SFP bills) may have more of an impact than notes and bonds. This is because previous research has shown that primary dealers purchase over 90% of CMBs and nearly 85% of 4-week Treasury bills, while the percentage for longer term Treasury securities is around 60% (Fleming, 2007). As dealers tend to hold CMB purchases, it is likely that shorter maturity securities are more likely to be pledged as collateral in funding markets (Fleming and Rosenberg, 2007). Also, some investors, such as money market mutual funds, need to hold down the weighted-average-maturity of their portfolios. Therefore, they typically invest in short-term instruments such as repo or Treasury bills, but not Treasury notes and bonds. As a result, an increase in bills can divert funds away from repo markets and drive up repo rates. This impact is separate from and in addition to the impact due to increased collateral supply, as primary dealers (the holders of securities) need to pay more to borrow funds. On the other hand, a corresponding increase in notes and bonds will not result in a direct diversion of funds from repo markets. And finally, buy-and-hold investors, such as insurance companies and sovereign entities, may prefer longer duration Treasury securities and these investors are unlikely to use their Treasury securities as collateral for repo transactions.

As controls we include measures of stress such as the Chicago Board Options Exchange Volatility Index (VIX), which measures the implied volatility of the S&P 500 index, the Merrill Lynch Global Financial Bond index option-adjusted spread (OAS), the change in the 1 Month spread between AA financial and non-financial commercial paper (CP), and the change in the 1 Month LIBOR-OIS (LOIS) spread. We further include calendar dummy variables for the beginning and end of quarters and years; times when demand for collateral may be impacted by reporting requirements.[25]

[25] The year-end and year-start dummy variables are additive to the quarter-end and quarter-start dummy variables, respectively. Sundaresan and Wang (2009) discuss seasonality in the spread between overnight repo rates and the fed funds target rate. LIBOR stands for the London

Table 3 presents summary statistics for the variables studied. Note the wide disparities between the mean values and the minimum and maximum values for the variable levels as well as changes of the variables in the table. The large range of values reflects the extreme distortions in financial markets experienced over our sample period.

‹Table 3 here›

We estimate the following regression and the results are presented in Table 4:

$$\Delta \text{FF target-GC repo rate spread}_t = \alpha + \beta^* \Delta \text{Treasury Collateral}_t + \gamma^* \Delta X_t + \varepsilon_t \qquad (1)$$

Herein, *Treasury Collateral*, takes on a few different forms; first as a single variable that combines all sub-types of collateral and then subsequently as a vector of differentiated sources of collateral. We expect the coefficients on our collateral measures will be negative such that an increase in Treasury collateral will lead to an increase in the GC rate and therefore, a *decrease* in the spread. However, as noted above, some sources of Treasury collateral may have a larger impact than others.

The variable X_t includes the controls listed above. We employ the VIX and the other interest rate spreads as controls because they may be associated with funding market stress. We focus on the 1 month CP and LOIS spreads because term funding became particularly scarce as counter-party and liquidity concerns escalated. These concerns may also be reflected in overnight collateralized borrowing costs, such as the GC rate. We expect that changes in the VIX and the various interest rate spreads will be positively related to the change in the spread.

Interbank Offered Rate which is a daily reference rate for inter-bank unsecured borrowing. OIS stands for Overnight Indexed Swap which is referenced to the daily federal funds rate.

Taylor and Williams (2009) employ a LOIS spread as a dependent variable, however they express some concern about LIBOR validity due to the self-reported nature of rates by surveyed banks. McAndrews, Sarkar, and Wang (2008) document LIBOR reports in line with expected market reactions. Similarly, Gorton and Metrick (2011) devote a good deal of work to documenting LOIS and several other asset-class spreads and include documentation of exploding haircuts in their descriptive analysis of several dimensions of the 2007-2008 period. As compared to our current work, all three papers focus primarily on the early 2007-2008 time period, and in the cases of the first two papers, the Term Auction Facility, which was introduced by the Federal Reserve in late 2007.

IV. Results

Table 4 presents results for the spread using the fed funds rate target over the full sample period from January 2007 through May 2010.[26] Columns 1-6 present Ordinary Least Squares (OLS) regression results. The first column combines all sources of Treasury collateral. The observed relationship with our dependent spread variable is, as expected, negative and statistically significant.

‹Table 4 here›

The second column breaks out the sources of Treasury collateral into seven categories: TSLF, SFP, Treasury bills, Treasury notes and bonds, temporary OMOs, SOMA bills, and SOMA notes and bonds. We can reject the null hypothesis of equal coefficients between columns one and two at the 95% confidence level. We find that five of the Treasury collateral coefficients have the expected negative sign. Four of the negative coefficients are statistically significant. The largest estimated coefficient is for the TSLF. The estimate suggests that every $1 billion increase in Treasury collateral due to TSLF is correlated with a narrowing of the FF-Repo spread by roughly 1.12 basis points. This suggests that the TSLF program was effective at narrowing the wide spreads between the Treasury GC repo rate and the fed funds target during the financial crisis.

The remaining statistically significant negative coefficients are all roughly of the same magnitude: SFP coefficient (-0.137), Treasury bills (-0.150), and Treasury notes and bonds (-0.142). The TSLF coefficient is statistically different from the SFP, Treasury bills, and Treasury notes and bonds coefficients at the 95% confidence level. We find no evidence of a statistically significant difference in impact between the SFP, Treasury bills and Treasury notes and bonds.

[26] Appendix Tables A.1 and A.2 report results for the effective federal funds rate (A.1) and over earlier and later sub-periods in the crisis and its aftermath (A.2). Results depicted in Table 4 generally hold throughout the tables in the appendix.

The temporary OMO coefficient estimate is positive, but small in magnitude and insignificant (see the discussion of temporary OMOs below). The positive sign and insignificance for the SOMA bills coefficient is not entirely surprising. As noted above, this variable takes on non-zero values on only seven dates, and is never negative (see Figure 4, bottom panel). We suggest that the coefficient is likely a spurious artifact.

We interpret these results broadly as follows. Given the design and structure of the program, it is likely that most, if not all, of the Treasury collateral supplied by the TSLF was employed in funding markets, while the smaller magnitude of the other collateral coefficients suggests that a smaller fraction of the collateral supplied by the SFP and other Treasury issuance was employed in funding markets as collateral. Nevertheless, the results show that responses to the crisis which were not directly aimed at funding markets nonetheless impacted short-term money markets, suggesting that some of the added supply from these other sources reached money markets.

Furthermore, our results show that the proper policy response to a financial crisis includes options which do not increase bank reserves. Short-term money markets were impaired over the course of our sample period and resulted in an imbalance in the supply and demand for Treasury collateral. We find that the most effective policy response involved the TSLF, which was reserve-neutral. We also find a non-negligible impact from Treasury collateral provided via SFP. Recall that the SFP was a program introduced to drain reserves from the banking system.

As regards other coefficients in the second column, we see that the OAS and LOIS spread coefficients are positive. This is consistent with flight-to-quality responses in times of stress; as stresses increase, market participants prefer to transact with high quality collateral such as Treasuries, which drives down the Treasury GC repo rate and increases the spread. The

coefficient for changes in the VIX is small and not statistically significant, which may not be surprising given that this measure is related to stresses in equity markets.

Returning now to temporary OMOs, the third column in Table 4 drops the temporary OMO variable as a generic robustness check on our remaining estimated coefficients. This specification is further warranted since virtually no temporary OMOs were conducted in the latter half of our sample period. None of the reported coefficients change in terms of magnitude or statistical significance in any meaningful way.

The fourth column of Table 4 includes the lagged spread as an independent variable. The lagged spread coefficient suggests some degree of reversion so that--for example, a widening of the spread on any given day is followed by a partially mitigating reduction on the following day, all else equal. Otherwise results are not dramatically different from column 2, except that neither the SFP nor Treasury issuance of bills coefficients are statistically different than zero (though their signs remains negative and their magnitudes are notably smaller). The positive SOMA bills coefficient is now much larger and statistically significant. However, by the bottom panel of Figure 4 and Figure 5, note that SOMA bills are drawn from the Fed's portfolio early in the crisis only on a small number of occasions, and unlike the notes and bonds purchased under LSAP, the bills position is never restored. As a result, there is a severe lack of identifying variation for this variable. The TSLF and Treasury notes and bonds coefficients are still significant at the 95% confidence level or above.

For another robustness check of the specification, given the concern in Taylor and Williams (2009) regarding LIBOR, the fifth column of Table 4 simply omits the LOIS variable. This does not appear to fundamentally alter the results in column 4.[27]

[27] See footnote 25 for more on this discussion of concerns regarding the LIBOR.

To examine the impact of the various sources of Treasury collateral within a counter-factual scenario of normal market functioning, column 6 expands the specification to include interaction variables. The inclusion of these terms represents an attempt to control for the impact of monetary policy tools within and outside of acute crisis periods. We interact each of the monetary policy measures separately with the level of the one month Treasury GC -to-Agency MBS repo rate spread—a proxy for market stress which compares two term collateralized funding rates in contrast to our dependent variable which compares an over-night uncollateralized rate and an overnight collateralized rate. This specification represents an attempt to distinguish whether the impact of TSLF was due to its generic impact on collateral or to its implementation as the financial crisis deepened.

After interacting each policy with our proxy for market stress, we can compare the specification in column 4 to that of column 6, and thereby differentiate crisis from general collateral impacts as follows: The TSLF coefficient in column 4 embeds both a crisis and a general collateral impact; whereas the stand-alone TSLF coefficient in column 6 estimates just a general collateral impact (with the GC-MBS spread set to a de minimus level), and the TSLF*(GC-MBS spread) coefficient reports a crisis impact. We note that all of the stand-alone coefficients are now negative.

In column 6, the stand-alone TSLF coefficient is no longer statistically significant at the 95% confidence level, but its magnitude is still sizable (-0.62 basis points per $billion). The other stand-alone coefficients are generally larger than column 4 equivalents, suggesting that sources of Treasury collateral such as sales of SOMA holdings, which have positive interaction coefficients, have more of an impact on the FF-Repo spread during times of normal market functioning than during times of stress. The TSLF interaction coefficient (-.009) suggests that

the impact of Treasury collateral injections via TSLF is conditional on stress in funding markets, though the coefficient is not statistically significant.

Column 7 presents results from a specification that follows the threshold ARCH (TARCH) model of Glosten, Jagannathan, and Runkle (1993). We estimate this model since the volatility of our dependent variable varies over our sample period (see Figure 1, bottom panel). By column 7 the stand-alone coefficients are all still negative. However, the TSLF stand-alone coefficient (-.06) is about a tenth the magnitude as it was via OLS (column 6) and it is not significant at any standard confidence level. And while the TSLF interaction coefficient (-.005) is also smaller in magnitude compared to its OLS estimate, it is now nearly significant at the 90% confidence level (absolute value t-statistic of 1.57). The TSLF interaction coefficient is now the largest coefficient in terms of magnitude amongst the negative interaction coefficients in column 7. And even with the smaller magnitude, the TSLF interaction coefficient would suggest a sizable impact of the program during a time of funding market stress. To illustrate, a $70 billion TSLF settlement with the GC-MBS spread at 200 bps (the values around the time of the Lehman bankruptcy), would result in a reduction in the FF-Repo spread of around 70 bps according to the TSLF interaction coefficient in column 7.

Accounting for non-constant volatility, the results in column 7 reinforce the results found in column 6. Together, these results suggest that the impact of the TSLF program is due more to its introduction and operation during a time of funding market stress and less from its direct impact on Treasury collateral. In other words, the TSLF program had a large impact on the FF-Repo spread because it was introduced and operated at a time when spreads were unusually wide. The TSLF would have had a much smaller impact if it had been introduced during a time of normal market functioning.

V. Discussion and Conclusion

In this study, we investigate the impact of Treasury collateral on overnight Treasury GC repo rates. In general we find the expected relationship, whereby increases in Treasury collateral increase repo rates and narrow the spread between repo rates and the fed funds target. These results are related to studies investigating the impact of Federal Reserve emergency liquidity facilities which were introduced in response to the financial crisis that began in the fall of 2007.

We find that the TSLF, which was introduced specifically to address stresses in short-term funding markets, was effective in alleviating the dislocations due to the increased demand for Treasury collateral as the crisis progressed. We also find that programs like the SFP and general Treasury issuance, which were aimed at the financial crisis but not short-term funding markets, in fact did also impact repo rates.

In addition, we provide evidence that the impact of the TSLF was due primarily to its introduction and operation during the financial crisis and less to its direct impact on Treasury collateral. That is, the TSLF was able to substantially impact repo rates because the program was introduced and was in effect at a time when these rates were severely dislocated. Further, the TSLF was unique in addressing counter-party risk. The TSLF would have had a much smaller effect on repo rates if the program had been introduced in a period of normal market functioning.

An implication of our results is that the proper policy response to a financial crisis may not necessarily involve a simple increase in bank reserves. For example, the TSLF program was very effective at alleviating short-term money market stresses during the financial crisis and this program was reserve-neutral; the increase in Treasury collateral from the SFP was also able to alleviate money market stress while actually draining reserves from the banking system.

Our results also suggest a modification of Bagehot's dictum that central banks should respond to a financial panic by lending early and freely at high rates, to solvent firms, against good collateral. During the financial crisis, securitized lending markets experienced an upheaval not because of a lack of cash, but because of a lack of high quality collateral. So what is to be lent in this situation is not so much money but rather high caliber collateral, and by increasing supplies of high caliber collateral, the Federal Reserve facilitated market functioning quite effectively.

APPENDIX:

Table A.1 mirrors results for the same sample as in Table 4, but with the dependent variable set as the change in the spread between the overnight Treasury GC repo rate and the effective fed funds rate.

‹Table A.1 here›

The results are very similar to the corresponding results in Table 4, even though the effective fed funds rate is subject to different dynamics, such as the level of excess reserves in the banking system, from the overnight Treasury GC repo rate. Generally the amplitudes of coefficients and their statistical significance improve in strength when engaging the effective spread. This is particularly true for the more generic Treasury issuance and SOMA bills.

Table A.2 compares the OLS results for the full period with results over two sub-periods, an early and later crisis period.

‹Table A.2 here›

The first three columns of Table A.2 correspond to Table 4. The first replicates the results from column 4 of Table 4, and the next two columns report on the same specification for the periods: January 2007 – December 15th 2008, and December 16th 2008 – May 2010 respectively. The final three columns repeat this pattern, this time using column 4 of Table A.1 as the anchor specification.

These sub-period results may be of interest as the sample from January 2007 through mid-December 2008 excludes observations after the FOMC adopted a target range of 0-25 bps for the fed funds rate instead of an explicit target rate. This sample thus avoids the need to pick a target rate against which to benchmark the GC rate. Also, given the low level of interest rates, it is highly unlikely that the FF-Repo spread will be greater than 25 bps, so that any increases in repo rates may be biased downward when the post-2008 sample is included. Sensitivity of the

dependent variable may therefore be quite different after December 16th 2008; however, excluding observations after December 2008 omits useful variation in Treasury collateral over the course of 2009 through May 2010. For example, this sample period misses the decline in TSLF outstanding over the first half of 2009, as well as the decline and subsequent build-up of the SFP after September 2009 (Figure 2). The results for the Treasury collateral coefficients show that only the TSLF coefficient is negative and statistically significant at the 95% level over this sample period. In fact, the Treasury notes and bonds coefficient is even positive. Similarly excluding observations from 2007 reduces the number of observations where programs like the TSLF and SFP were not in existence. Values for these variables were zero over the excluded period and therefore, there is no identifying variation. We note that over all sub periods the TSLF persists in being the largest negative coefficient in magnitude and most statistically significant policy response in alleviating stresses in money markets.

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Table 1: Treasury Issuance-- 2006 versus 2009

	2006		2009	
Type	Maturities	Schedule	Maturities	Schedule
Bills:				
	Cash-Management Bills	As Needed	Cash-Management Bills	As Needed
	4-week	Weekly	4-week	Weekly
	13-week	Weekly	13-week	Weekly
	26-week	Weekly	26-week	Weekly
			52-week	Each 4 weeks
Notes:				
	2-years	Monthly	2-years	Monthly
	3-years	Quarterly	3-years	Monthly
	5-years	Monthly	5-years	Monthly
	10-years	8 times a year	7-years	Monthly
			10-years	Monthly
Bonds				
	30-years	2 times a year	30-years	Monthly
Inflation-Indexed:				
	5-year Notes	2 times a year	5-year Notes	2 times a year
	10-year Notes	4 times a year	10-year Notes	4 times a year
	20-year Bonds	2 times a year	20-year Bonds	2 times a year

Source: U.S. Department of the Treasury

Table 2: Summary of Programs Impacting Treasury Collateral

Program	Primary Purpose	Expected Impact on Fed Funds-Repo Spread (regression coefficient)
TSLF	Alleviate Stresses in Funding Markets	$\beta_{TSLF}<0$
SFP	Drain Reserves from the Banking System	$\lvert\beta_{TSLF}\rvert \geq \lvert\beta_{SFP}\rvert$
Treasury Issuance	Fund Government Expenditures	$\lvert\beta_{TSLF}\rvert \geq \lvert\beta_{bills}\rvert \geq \lvert\beta_{notes\ and\ bonds}\rvert$
Open Market Operations		
Temporary	Target Fed Funds Rate	$\lvert\beta_{TSLF}\rvert \geq \lvert\beta_{TOMO}\rvert$
Permanent (includes Large Scale Asset Purchases)	Fund Currency Demand Adjust Federal Reserve Balance Sheet Reduce Long-Term Interest Rates	$\lvert\beta_{TSLF}\rvert \geq \lvert\beta_{POMO\ bills}\rvert \geq \lvert\beta_{POMO\ notes\ and\ bonds}\rvert$

Table 3: Summary Statistics

	Mean	Std. Dev.	Min	Max
(FF target-GC rate) (bps)	25.3	37.4	-30.0	300.0
OAS (bps)	266.5	169.6	59.0	686.0
VIX (%)	26.5	12.6	9.9	80.9
1 Month AA Financial-Non-Financial CP (bps)	16.2	26.7	-14.0	236.0
1 Month LIBOR-OIS (bps)	35.9	49.2	3.7	337.8
Δ(FF target-GC rate) (bps)	-0.029	21.91	-220.0	195.0
ΔTSLF ($b)	0.000	4.99	-47.2	75.0
ΔTsy Bills ($b)	0.833	10.54	-55.0	70.0
ΔTsy Notes and Bonds ($b)	3.167	14.54	-54.8	99.0
ΔSFP ($b)	0.234	10.01	-75.0	60.0
ΔSOMA Bills ($b)	0.104	1.18	0.0	18.0
ΔSOMA Notes and Bonds ($b)	-0.297	1.54	-8.5	5.0
ΔShort Term OMOs ($b)	0.024	4.38	-26.0	25.0
ΔOAS (bps)	0.218	4.58	-37.0	41.0
ΔVIX (%-age points)	0.024	2.56	-17.4	16.5
Δ1 Month AA Financial-Non-Financial CP (bps)	0.008	14.69	-106.0	146.0
Δ1 Month LIBOR-OIS (bps)	0.007	6.20	-44.2	50.4

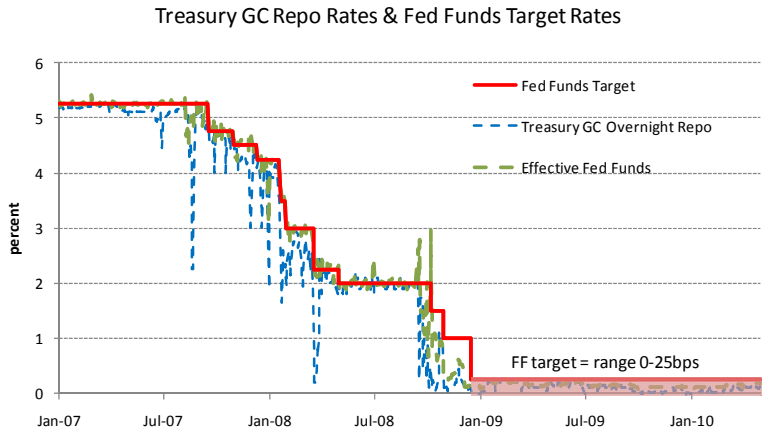
Sample: 1/2/07-5/28/10
obs. = 854 (diffs obs.= 853)

Table 4: Target Federal Funds- Treasury General Collateral Repo Rate Spread Analysis

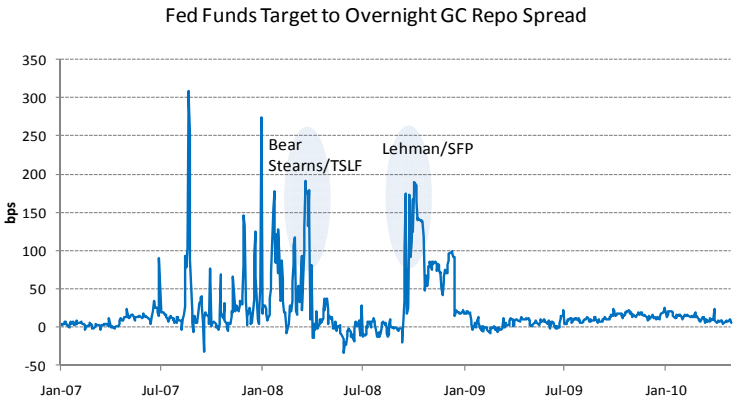
VARIABLES	1	2	3	4	5	6	7
(all expressed as first differences unless noted)	*full observation range of January 2007 - May 2010*						
US Treasury issuance, total	-0.217***						
	(0.06)						
Term Securities Lending Facility		-1.124***	-1.124***	-0.996***	-0.967***	-0.619	-0.060
(TSLF)		(0.33)	(0.33)	(0.31)	(0.32)	(0.52)	(0.08)
Supplemental Financing Program		-0.137*	-0.137*	-0.032	-0.026	-0.117	-0.070***
(SFP)		(0.09)	(0.09)	(0.09)	(0.09)	(0.14)	(0.03)
US Treasury issuance, Bills		-0.150**	-0.151**	-0.092	-0.092	-0.012	-0.011
(T.Bill)		(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.01)
US Treasury issuance, Notes & Bonds		-0.142***	-0.142***	-0.127**	-0.126**	-0.109*	-0.049***
(T.NB)		(0.05)	(0.05)	(0.05)	(0.05)	(0.0558)	(0.01)
Temporary Open Market Operations		0.012		0.064	0.108	-0.205	-0.048
(STOMO)		(0.17)		(0.18)	(0.18)	(0.188)	(0.04)
System Open Market Accounttransactions, Bills		0.558	0.561	1.43**	1.33**	-1.78	-0.626
(SOMA.Bill)		(0.61)	(0.61)	(0.68)	(0.63)	(1.19)	(4.68)
SOMA transactions, Notes & Bonds		-0.112	-0.113	0.141	0.079	-0.368	-0.276***
(SOMA.NB)		(0.29)	(0.28)	(0.21)	(0.22)	(0.24)	(0.07)
TSLF -by- (GC-MBS)						-0.009	-0.005
measure: interaction term						(0.02)	(0.003)
T-Bill -by- (GC-MBS)						-0.004	-0.0036**
measure: interaction term						(0.003)	(0.001)
T.NB -by- (GC-MBS)						0.0016	0.001
measure: interaction term						(0.01)	(0.001)
SFP -by- (GC-MBS)						0.0038	-0.0015
measure: interaction term						(0.003)	(0.001)
SOMA.NB -by- (GC-MBS)						-0.0125	0.026**
measure: interaction term						(0.02)	(0.01)
SOMA.Bill -by- (GC-MBS)						0.037***	0.001
measure: interaction term						(0.01)	(0.06)
STOMO -by- (GC-MBS)						0.009	0.028***
measure: interaction term						(0.01)	(0.002)
General Collateral-Mortgage Backed Security Repo Spread						0.294***	-0.0198***
(1 Month GC-MBS) source: Bloomberg						(0.0760)	(0.01)
Global Financial Bond Index Option-Adjusted Spread	0.303	0.372	0.372	0.486*	0.641**	0.211	0.231***
(OAS) source: Merrill Lynch	(0.260)	(0.28)	(0.28)	(0.28)	(0.32)	(0.23)	(0.03)
Options Exchange Volatility Index	0.113	-0.041	-0.042	-0.092	0.022	-0.049	-0.033
(VIX) source: Chicago Board of Trade	(0.310)	(0.32)	(0.32)	(0.32)	(0.28)	(0.31)	(0.06)
AA [Financial - Non Financial] Comercial Paper	-0.019	-0.024	-0.024	-0.021	-0.01	-0.032	-0.153***
(1 month CP spread)	(0.045)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.01)
London Interbank Offered Rate - Overnight Index Swap	0.417*	0.455**	0.455**	0.441*		0.478**	0.166***
(1 month LOIS spread)	(0.217)	(0.22)	(0.22)	(0.23)		(0.20)	(0.02)
Lagged Federal Funds GC Repo Spread				-0.148***	-0.149***	-0.286***	-0.116***
measure: one-day lag				(0.04)	(0.04)	(0.05)	(0.01)
Quarter end	39.80***	36.98***	36.97***	36.19***	37.22***	33.64***	7.856***
measure: binary	(8.17)	(8.02)	(8.02)	(8.22)	(8.37)	(8.18)	(1.52)
Quarter start	-34.00***	-34.35***	-34.35***	-31.15***	-30.79***	-28.24***	-6.45***
measure: binary	(9.54)	(10.27)	(10.26)	(9.05)	(8.76)	(9.50)	(1.85)
Year end	32.24	32.01	32.01	33.94	33.08	27.39	-3.509
measure: binary	(47.44)	(48.86)	(48.83)	(50.13)	(50.56)	(51.66)	(19.54)
Year start	-33.76	-33.77	-33.81	-27.10	-27.76	-21.78	4.87
measure: binary	(45.16)	(45.08)	(45.06)	(38.20)	(39.01)	(34.41)	(3.11)
Constant	0.78	0.448	0.449	3.97***	3.94***	1.323	1.95***
	(0.58)	(0.63)	(0.63)	(0.83)	(0.83)	(0.98)	(0.17)
ARCH							1.239***
							(0.16)
TARCH							1.60***
							(0.29)
GARCH							0.132***
							(0.02)
Constant							3.919***
							(0.57)
Number of Observations	853	853	853	853	853	853	853

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

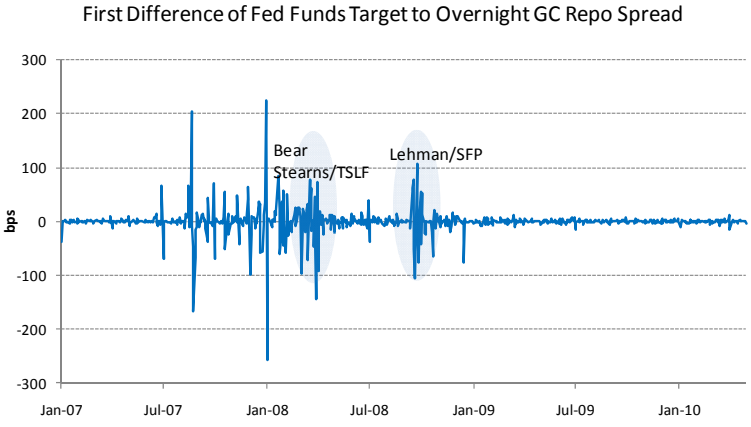
Figure 1: The Repo-Fed Funds Spread: 2007-2010



Source: Federal Reserve Bank of New York and Bloomberg

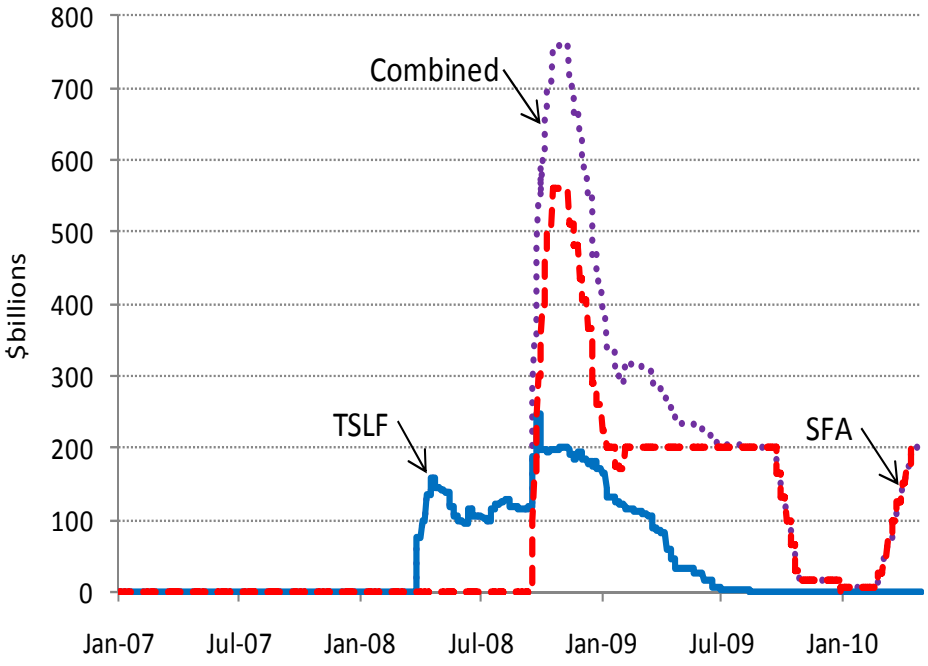


Source: Federal Reserve Bank of New York and Bloomberg



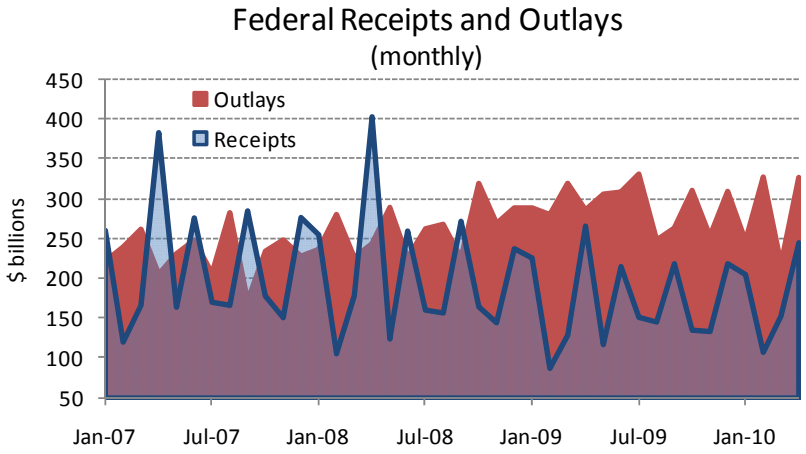
Source: Federal Reserve Bank of New York and Bloomberg

Figure 2: The Term Securities Lending Facility & Supplementary Financing Account: 2007 -2010

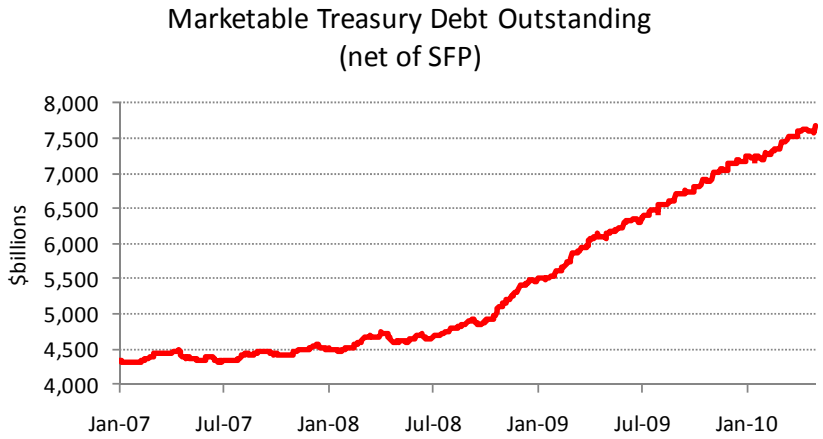


Source: Federal Reserve Bank of New York and Daily Treasury Statement

Figure 3: Federal Receipts and Outlays & Marketable Treasury Collateral: 2007 – 2010

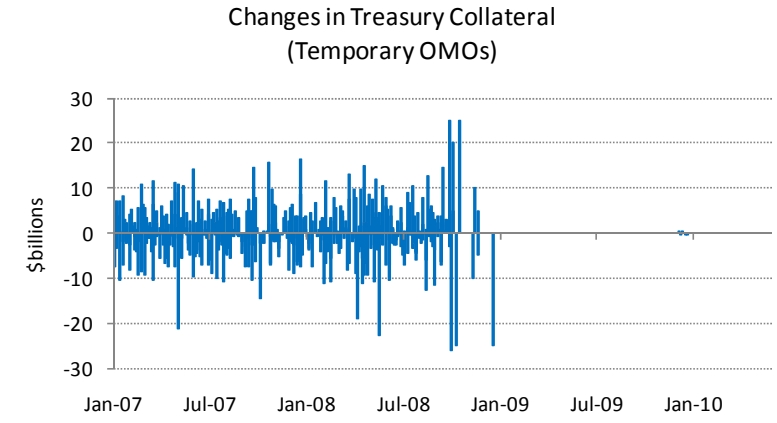


Source: Monthly Treasury Statement

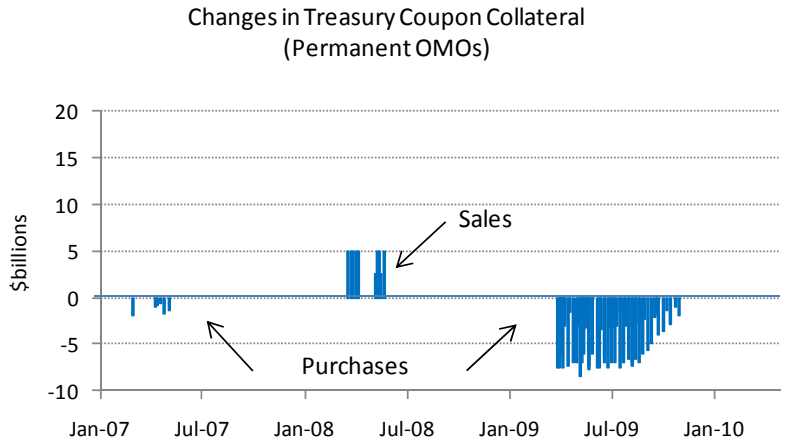


Source: Daily Treasury Statement

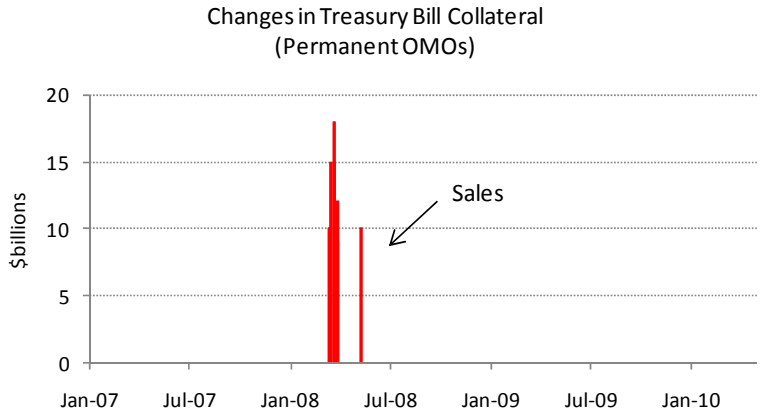
Figure 4: Open Market Operation Impacts on Treasury Collateral, 2007-10



Source: Federal Reserve Bank of New York

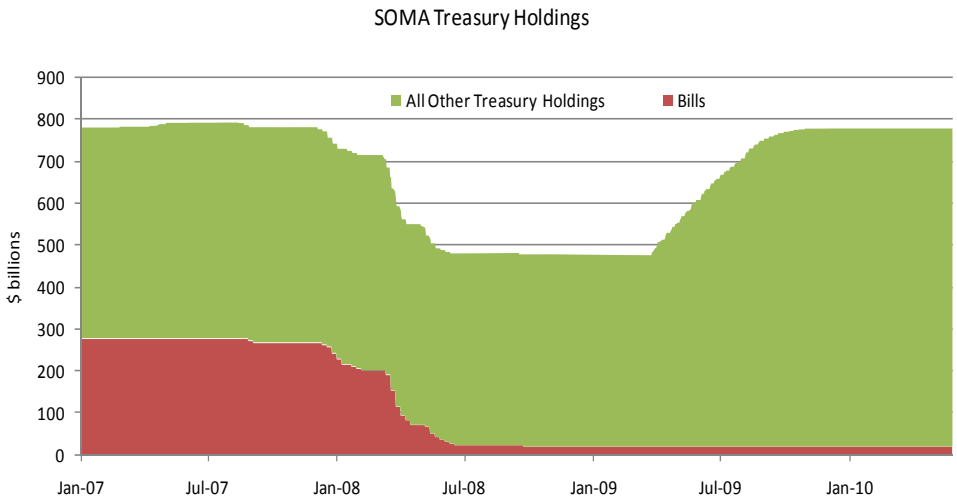


Source: Federal Reserve Bank of New York



Source: Federal Reserve Bank of New York

Figure 5: SOMA Treasury Holdings: 2007 – 2010



Source: Federal Reserve Bank of New York

Table A.1: Effective Federal Funds-Treasury General Collateral Repo Rate Spread Analysis

VARIABLES	1	2	3	4	5	6	7
(all expressed as first differences unless noted)	*full observation range of January 2007 - May 2010*						
US Treasury issuance, total	-0.240***						
	(0.09)						
Term Securities Lending Facility		-1.215***	-1.219***	-0.925**	-0.900**	-0.774	0.0736
(TSLF)		(0.47)	(0.48)	(0.38)	(0.40)	(0.50)	(0.07)
Supplemental Financing Program		-0.21	-0.201	-0.071	-0.069	0.067	-0.020
(SFP)		(0.18)	(0.19)	(0.17)	(0.17)	(0.21)	(0.03)
US Treasury issuance, Bills		-0.163**	-0.150*	-0.140**	-0.141**	-0.141**	0.012
(T.Bill)		(0.08)	(0.08)	(0.07)	(0.06)	(0.06)	(0.02)
US Treasury issuance, Notes & Bonds		-0.100**	-0.098**	-0.092**	-0.092**	-0.101**	-0.046***
(T.NB)		(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.01)
Temporary Open Market Operations		-0.448		-0.412	-0.356	-0.755**	-0.042
(STOMO)		(0.37)		(0.37)	(0.37)	(0.36)	(0.07)
System Open Market Accounttransactions, Bills		1.028	0.941	2.515***	2.302***	-1.114	-1.359
(SOMA.Bill)		(0.95)	(0.92)	(0.92)	(0.84)	(1.39)	(15.59)
SOMA transactions, Notes & Bonds		0.0129	0.0501	0.3870	0.2855	-0.430	-0.155*
(SOMA.NB)		(0.30)	(0.30)	(0.28)	(0.28)	(0.28)	(0.08)
TSLF -by- (GC-MBS)						-9E-04	-0.006
measure: interaction term						(0.01)	(0.004)
T-Bill -by- (GC-MBS)						-0.002	-0.0003
measure: interaction term						(0.003)	(0.001)
T.NB -by- (GC-MBS)						0.006	.004***
measure: interaction term						(0.005)	(0.001)
SFP -by- (GC-MBS)						-0.002	-0.0003
measure: interaction term						(0.01)	(0.00)
SOMA.NB -by- (GC-MBS)						0.012	-0.011
measure: interaction term						(0.04)	(0.02)
SOMA.Bill -by- (GC-MBS)						0.041**	0.053
measure: interaction term						(0.02)	(0.19)
STOMO -by- (GC-MBS)						0.011	-0.002
measure: interaction term						(0.01)	(0.003)
General Collateral-Mortgage Backed Security Repo Spread						0.324***	0.011
(1 Month GC-MBS) source: Bloomberg						(0.08)	(0.01)
Global Financial Bond Index Option-Adjusted Spread	0.261	0.345	0.359	0.508	0.705*	0.233	0.009
(OAS) source: Merrill Lynch	(0.324)	(0.36)	(0.35)	(0.37)	(0.43)	(0.30)	(0.03)
Options Exchange Volatility Index	0.277	0.041	0.081	-0.077	0.080	-0.099	-0.011
(VIX) source: Chicago Board of Trade	(0.38)	(0.34)	(0.33)	(0.30)	(0.27)	(0.32)	(0.06)
AA [Financial - Non Financial] Comercial Paper	-0.004	-0.002	-0.012	0.025	0.038	0.014	-0.012
(1 month CP spread)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.02)
London Interbank Offered Rate - Overnight Index Swap	0.395	0.466	0.442	0.59**		0.758***	.623***
(1 month LOIS spread)	(0.30)	(0.30)	(0.30)	(0.27)		(0.22)	(0.03)
Lagged Federal Funds GC Repo Spread				-0.242***	-0.232***	-0.400***	-.071***
measure: one-day lag				(0.05)	(0.05)	(0.06)	(0.01)
Quarter end	50.73***	45.31***	45.40***	44.49***	45.89***	41.60***	3.427***
measure: binary	(13.17)	(12.01)	(12.29)	(11.75)	(11.95)	(9.98)	(0.75)
Quarter start	-43.66***	-43.82***	-43.9***	-36.06***	-35.96***	-31.21***	0.0306
measure: binary	(16.42)	(16.44)	(17.13)	(13.55)	(13.23)	(13.23)	(1.51)
Year end	-9.903	-10.73	-10.699	-9.914	-11.110	-22.778	-3.776
measure: binary	(23.64)	(25.78)	(26.02)	(26.36)	(26.90)	(28.08)	(5.59)
Year start	5.3	3.521	4.766	4.232	3.252	4.830	1.461
measure: binary	(27.70)	(27.24)	(27.98)	(21.27)	(22.28)	(20.41)	(2.81)
Constant	0.836	0.354	0.335	4.108***	3.870***	-0.200	1.337***
	(0.62)	(0.65)	(0.65)	(0.66)	(0.64)	(1.06)	(0.20)
ARCH							.672***
							(0.07)
TARCH							.340***
							(0.11)
GARCH							.510***
							(0.02)
Constant							1.026***
							0.31
Number of Observations	853	853	853	853	853	853	853

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.2: Analysis over alternate sub-periods of crisis

VARIABLES (all expressed as first differences unless noted)	Table 4 comparatives			Table A.1 comparatives		
Alternate time periods:	1/07-5/10	1/07-12/08	1/08-5/10	1/07-5/10	1/07-12/08	1/08-5/10
	Table 4, col. 4			Table A.1, col. 4		
Term Securities Lending Facility (TSLF)	-.996*** (0.31)	-1.115*** (0.31)	-1.017*** (0.30)	-0.925** (0.38)	-1.049*** (0.40)	-0.92*** (0.366)
Supplemental Financing Program (SFP)	-0.032 (0.09)	0.0168 (0.12)	-0.055 (0.08)	-0.0706 (0.17)	-0.0817 (0.25)	-0.078 (0.158)
US Treasury issuance, Bills (T.Bill)	-0.092 (0.07)	-0.0772 (0.11)	-0.090 (0.08)	-0.140** (0.07)	-0.1388 (0.10)	-0.112 (0.076)
US Treasury issuance, Notes & Bonds (T.NB)	-0.127** (0.05)	0.0807 (0.18)	-0.057** (0.03)	-0.092** (0.04)	0.2561 (0.19)	-0.06* (0.037)
Temporary Open Market Operations (STOMO)	0.064 (0.18)	0.0960 (0.17)	-0.051 (0.26)	-0.412 (0.37)	-0.3815 (0.37)	-0.829 (0.567)
System Open Market Accounttransactions, Bills (SOMA.Bill)	1.43** (0.68)	1.222* (0.64)	1.267** (0.62)	2.515*** (0.92)	2.290*** (0.85)	2.54*** (0.919)
SOMA transactions, Notes & Bonds (SOMA.NB)	0.141 (0.21)	1.2859 (1.07)	0.171 (0.22)	0.387 (0.28)	2.196* (1.27)	0.372 (0.300)
Global Financial Bond Index Option-Adjusted Spread (OAS) source: Merrill Lynch	0.486* (0.28)	0.798* (0.46)	0.453 (0.287)	0.508 (0.37)	0.737 (0.65)	0.478 (0.387)
Options Exchange Volatility Index (VIX) source: Chicago Board of Trade	-0.092 (0.32)	-0.3492 (0.47)	-0.161 (0.319)	-0.077 (0.30)	-0.238 (0.45)	-0.093 (0.295)
AA [Financial - Non Financial] Comercial Paper (1 month CP spread)	-0.021 (0.05)	-0.0360 (0.05)	-0.001 (0.042)	0.025 (0.06)	0.002 (0.07)	0.063 (0.068)
London Interbank Offered Rate - Overnight Index Swap (1 month LOIS spread)	0.441* (0.23)	0.416* (0.24)	0.420* (0.237)	0.59** (0.27)	0.580** (0.27)	0.60** (0.314)
Lagged Federal Funds GC Repo Spread measure: one-day lag	-0.148*** (0.04)	-0.144*** (0.04)	-0.127*** (0.037)	-0.242*** (0.05)	-0.244*** (0.05)	-0.24*** (0.051)
Quarter end measure: binary	36.19*** (8.22)	46.54*** (10.01)	27.33*** (9.068)	44.49*** (11.75)	60.87*** (11.86)	44.08*** (16.419)
Quarter start measure: binary	-31.15*** (9.05)	-51.85*** (10.59)	-27.97** (11.675)	-36.06*** (13.55)	-61.710*** (17.94)	-39.57** (18.156)
Year end measure: binary	33.94 (50.13)	140.14*** (9.48)	-22.09** (8.825)	-9.914 (26.36)	24.64** (11.68)	-39.39** (16.758)
Year start measure: binary	-27.1 (38.20)	-57.655 (57.47)	-42.326 (50.704)	4.232 (21.27)	6.437 (29.29)	3.064 (28.387)
Constant	3.97*** (0.83)	4.21*** (0.92)	3.65*** (0.896)	4.108*** (0.66)	4.97*** (1.17)	3.92*** (0.757)
Number of Observations	853	490	603	853	490	603

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1