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### The Effects of Federal Reserve Liquidity Facilities On Inter-Bank Borrowing Rates

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# The Effects of Federal Reserve Liquidity Facilities On Inter-Bank Borrowing Rates

Isaac Green

Economics Honors Program 2012-2013

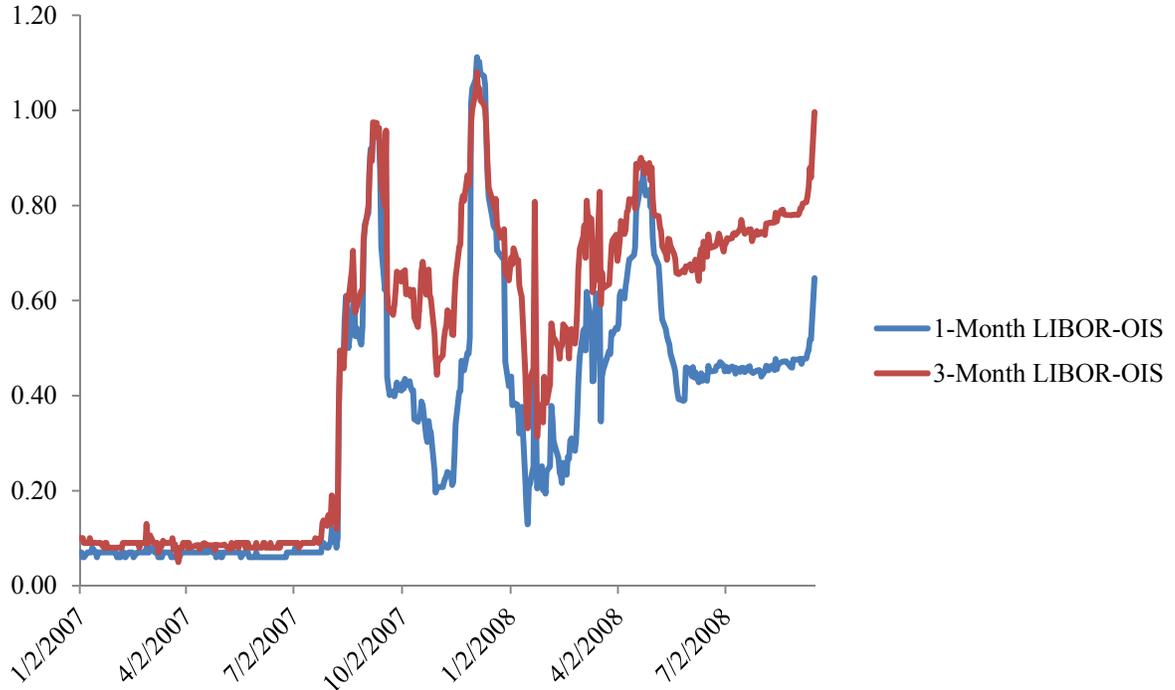
## **Abstract**

In the summer of 2007, stress in money markets created concern among economic policymakers. Fears of counter-party risk and concerns regarding the quality of bank collateral caused tremendous funding pressures for commercial and investment banks, which relied heavily on short-term borrowing. Initial attempts by the Federal Reserve to provide liquidity to banks and to alleviate strains in money markets through conventional monetary policy channels proved ineffective. After a sustained period of financial stress, the Federal Reserve introduced several programs in late 2007 and in early 2008 to address the liquidity needs of market participants. These programs were geared toward addressing the shortcomings of the Fed's existing monetary tools and toward providing emergency liquidity to banks facing funding pressures. In this paper, I analyze the effectiveness of several of these facilities, including the Term Auction Facility (TAF), the Primary Dealer Credit Facility (PDCF), the Term Securities Lending Facility (TSLF), and foreign exchange swap lines. To assess the impact of these facilities, I estimate their effectiveness in lowering spreads of the 1-month and 3-month London Inter-Bank Offered Rate (LIBOR) over the Overnight Index Swap (OIS) rates of the same maturities. I develop a reduced form model of LIBOR-OIS spreads from August 2007 to September 2008, guided by an analysis of the financial environment during that period. By creating variables related to the size, in dollars, of various Federal Reserve facilities, I am able to estimate the separate effects of each facility on inter-bank borrowing rates. My analysis also estimates the effects of announcements, auctions, and settlements related to a particular facility. Empirical findings indicate that the TAF lowered LIBOR-OIS spreads during the early part of the sample period, becoming less effective toward the end of the period as financial pressures became more concentrated among investment banks and non-bank institutions. Results also indicate that the PDCF, TSLF, and swap lines were less effective at reducing borrowing rates during this period.

## 1. Introduction

In 2007, turmoil in money markets presented economic policy makers with severe challenges regarding the availability of liquidity in short term funding markets. Concerns regarding the residential mortgage market and financial products related to that market emerged early in the year. In the summer of 2007, huge losses by hedge funds that traded mortgage-backed securities and related products fueled concern regarding counterparty risk in the banking system. In early August, interest rates in money markets spiked, as the spread of the 3-Month London Interbank Offered Rate (LIBOR) over the 3-Month Overnight Index Swap (OIS) rate jumped from under 10 basis points in early August to over 100 basis points later that month.<sup>1</sup>

### LIBOR-OIS Spread 2007-2008



<sup>1</sup> Wu, Tao, 2008, page 1

In response to heightened financial stress, central banks around the world cut interest rates and eased their monetary policy stances. Initial attempts by the United States Federal Reserve to ease borrowing rates in interbank markets through conventional monetary policy were ineffective. As a result, in late 2007 and 2008, the Federal Reserve established several new programs to deliver liquidity to financial markets. These Programs included the Term Auction Facility (TAF), foreign exchange swap lines, the Term Securities Lending Facility (TSLF), and the Primary Dealer Credit Facility (PDCF).<sup>2</sup> With the TAF and swap lines programs, the Fed sought to proactively inject liquidity into financial markets instead of relying on commercial banks to approach the Fed's discount window. With the creation of the TSLF the Fed sought to ease conditions in the repo markets relied upon by investment banks, while the PDCF was designed to allow investment banks to access emergency liquidity in much the same way that commercial banks are allowed to access the Federal Reserve's discount window.

This paper seeks to analyze the effects of these programs by assessing their impact on the 1-Month and 3-Month LIBOR-OIS spreads. Existing literature on Federal Reserve liquidity facilities is inconclusive. Research on the TAF program has suggested that it played a role in reducing the LIBOR-OIS spread in the early part of 2008, while analysis of the TSLF has suggested that it may have lowered spreads between general collateral repo rates and treasury bonds. Authors of recent papers on liquidity facilities disagree on which days Federal Reserve policies would affect LIBOR-OIS spreads as well as the proper econometric approach to use when assessing the impact of these programs. My analysis seeks to advance the existing literature in several ways. First, I focus on several liquidity facilities and attempt to assess their

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<sup>2</sup> Other facilities included the Commercial Paper Funding Facility (CPFF), the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), and the Money Market Investor Funding Facility (MMIFF), which are not the focus of this paper.

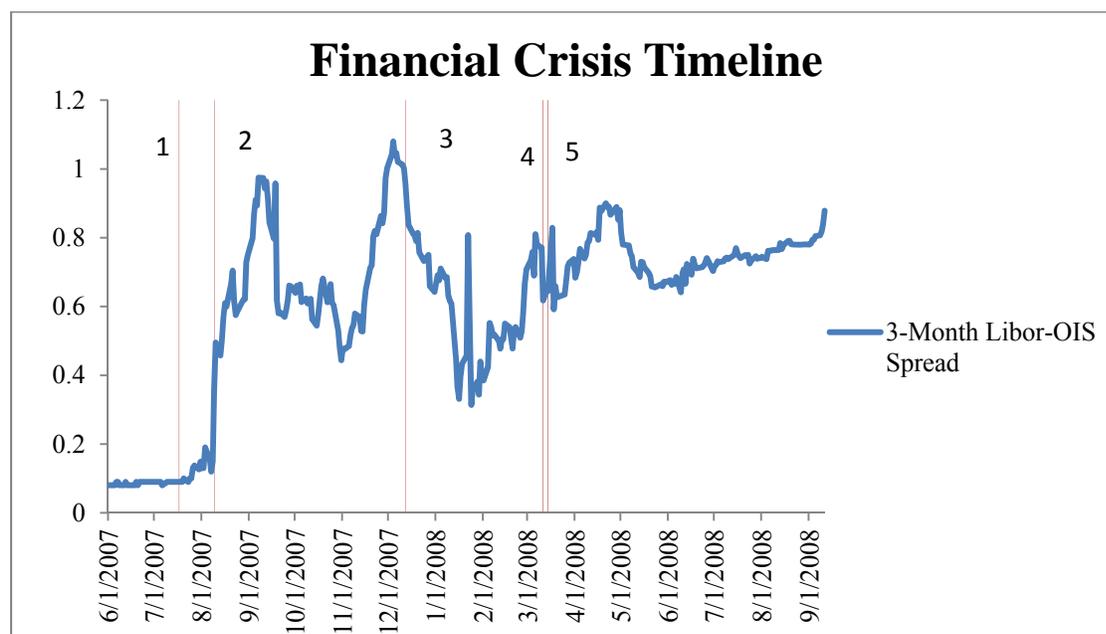
joint effects on the LIBOR-OIS rate. I also create quantitative variables related to the size of the programs instead of using the dummy variables favored in existing literature. Finally, I examine the effects of Federal Reserve programs both on days in which the Fed announced these programs and on the days the facilities operated. In developing my analysis, I use daily time-series financial data from the beginning of 2007 until early September 2008, ending the sample immediately prior to the collapse of Lehman Brothers.

The rest of the paper is organized as follows. Section 2 describes the issues confronting economic policy makers in the 2007-2008 financial crisis, introduces the Federal Reserve programs, and gives a conceptual overview of the designs and goals of these programs. Section 3 presents a review of literature on Federal Reserve liquidity facilities and describes the data used. Section 4 presents the regression models used in describing the effects of Federal Reserve liquidity facilities and discusses the results of the study. Section 5 concludes.

## **2.1 Overview of the Financial Crisis**

The liquidity concerns that plagued financial markets beginning in August 2007 stemmed from the deterioration of mortgage related assets over the preceding months. While concerns regarding elevated default rates among subprime borrowers emerged in early 2007, these concerns did not affect borrowing rates for financial institutions until investors began to suspect that large banks might be heavily exposed to subprime assets. On July 17<sup>th</sup>, 2007, Bear Stearns, a large investment bank, announced that one of its hedge funds had lost all of its value while another had lost 91% of its value since April of that year precipitating fears that large financial institutions would suffer losses and have to recapitalize hedge funds that invested in subprime mortgage products.

Meanwhile, despite depressed stock prices and financial volatility, the Federal Reserve decided in its August 7<sup>th</sup> announcement to leave the target Federal Funds rate unchanged in order to combat inflation, noting that “although the downside risks to growth have increased somewhat, the Committee’s predominant policy concern remains the risk that inflation will fail to moderate as expected.”<sup>3</sup> Two days later, on August 9<sup>th</sup>, an announcement by the French bank BNP Paribas that it was unable to value assets in some of its investment funds due to “the complete evaporation of liquidity in certain market segments of the U.S. securitization market” caused short term interest rates to spike, catalyzing a sustained period of financial stress, which would last throughout the year.<sup>4</sup> The announcements by Bear Stearns and BNP Paribas ignited fears of counterparty risk in the banking system. While the size and location of subprime exposure were not known, the announcements by Bear and BNP fueled the concern that large financial institutions might face substantial losses due to their exposure to subprime mortgages and other risky financial products.



<sup>3</sup> <http://www.federalreserve.gov/newsevents/press/monetary/20070807a.htm>

<sup>4</sup> Term Auction Facility: Origin, Design and Effects

1: Bear Stearns Hedge funds announce massive losses 2: BNP Paribas announcement 3: TAF and Swap Lines established 4: TSLF announcement 5: PDCF announcement and announcement of sale of Bear Stearns to JP Morgan Chase

The evaporation of liquidity beginning in August, 2007, also stemmed from a host of long-term developments in banking and financial markets. The crisis emerged on the tail end of a sustained period of strong housing demand, which was buttressed by rising home prices and financial innovation. One such innovation was the rise of subprime lending, which flourished as a result of ostensibly improved techniques to gauge default risk among potential borrowers.<sup>5</sup> The proliferation of subprime borrowing was also driven by the process of securitization. In this process, banks purchased mortgages and other loans from originators, pooled them together, and created securities whose payoffs were determined by the cash flows from the assets in the pool. These securities were then sold to institutional investors as well as to other commercial and investment banks. The process of securitization opened a new channel for mortgage funding. While traditionally, banks made loans to homebuyers, which they held on their balance sheets, securitization allowed participants in capital markets to invest in residential mortgages. Securitization also allowed the redistribution of risk to investors with different levels of risk tolerance by dividing mortgage-backed securities into structured products that were designed to contain various amounts of risk.<sup>6</sup>

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<sup>5</sup> Subprime refers to mortgages provided to those deemed too risky to qualify for traditional mortgage products such as 30 year fixed rate loans (as noted in Gorton and Metrick, 2008). This could include those with poor credit histories, low or unreported income, or a lack of assets or collateral.

<sup>6</sup> Typically, structured finance vehicles related to residential mortgages were divided into tranches which differed in their seniority. The most risky tranche, often referred to as the equity tranche, would absorb all of the losses on the pool of mortgages until all its value was wiped out, at which point the next riskiest tranche, the mezzanine tranche would absorb subsequent losses, and so on. The senior most tranches would generally only lose value if the underlying mortgages suffered losses of 20-30% or more, a low probability event under the assumption that there was low correlation between cash flows associated with different mortgages within the pool.

Another structural change to the banking sector in the years preceding the crisis was the increased reliance by banks on short-term borrowing in capital markets, rather than on demand deposits, as a primary source for funding their balance sheets. The markets relied upon most heavily by banks for short-term funding were the markets for repurchase agreements (repo) and commercial paper. In repo markets, borrowers obtain funds by selling collateral to investors and agreeing to repurchase the collateral at a later date for a price exceeding the original sale price. The difference between the original sale price of the collateral and the repurchase price represents the interest rate, or repo rate, that a borrower in repo markets must pay. In the event that a borrower in repo markets is unable to meet the conditions of the repo agreement, thereby defaulting on the loan, the lender of funds may take possession of, and often sell, collateral pledged in the repo transaction. In addition to the risk that a borrower may default, the lender in a repo transaction also faces the risk that pledged collateral will lose value over the course of the transaction or that the collateral will be illiquid, or difficult to sell in the event of a borrower default. In order to compensate for these risks, in addition to charging a repo rate, a lender may also impose a “haircut” on the collateral pledged in the transaction. A haircut is the difference between the value of collateral pledged in a repo transaction and the size of the loan. A haircut of 25%, for example, would mean that a borrower would have to pledge \$100 of collateral for every \$75 borrowed.

Another source of funding for financial institutions was the commercial paper market. Commercial paper can be either unsecured or asset-backed. Unsecured commercial paper takes the form of promissory notes with fixed maturities from 1 to 270 days. In these transactions, the credit rating of the issuing institution is of key importance, since the lender is not automatically

entitled to seize assets from the borrower in the event of default. Asset backed commercial paper (ABCP), in contrast, is collateralized by financial assets.<sup>7</sup>

As securitized banking evolved, Asset-Backed Securities (ABSs), such as Residential Mortgage-Backed Securities (RMBS) became prominent in repo and asset-backed commercial paper transactions. These transactions rely on high quality collateral that is unlikely to lose significant value over duration of the loan. As repo transactions grew in prominence, the demand for safe assets began to outstrip supply. Gorton and Metrick (2008) argue that the process of securitization was driven by excess demand for high-rated collateral (AA or AAA), which led the banking sector to manufacture structured products, which through diversification and well-behaved default models, gained high credit ratings. These products could then be sold to investors, who sought the high returns of ABSs and other structured products relative to traditional AAA-rated instruments such as U.S. Treasury securities.

The ability to use Asset-Backed Securities as collateral when borrowing in money markets became crucial to the operations of large financial institutions in the U.S. and Europe. A few figures shed light on the importance of securitization in financial markets: Residential Mortgage related instruments represent the largest portion of fixed income issued in the United States, and even excluding RMBSs, the issuance of asset-backed securities exceeded the issuance of all corporate debt in 2004, 2005, and 2006.<sup>8</sup> Meanwhile, various sources estimate the size of the U.S. repo market at its 2007 peak was around \$10 trillion.<sup>9</sup> The commercial paper market

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<sup>7</sup> The issuance of asset backed commercial paper involves the sale of collateral, by the issuing institution, to an off-balance-sheet entity called a special purpose vehicle (SPV). The purpose of this sale is that collateral sold to SPVs is remote from bankruptcy. If the issuer of asset backed commercial paper goes bankrupt, while the SPV itself remains solvent, holders of its debt may not seize and sell collateral in SPVs. Therefore investors in ABCP are exposed only to the cash flows associated with loans in the SPV and not the credit risk of the issuing institution.

<sup>8</sup> Gorton and Metrick, 2008, page 8

<sup>9</sup> Gorton and Metrick, 2008, page 12

also experienced considerable growth in the late 20<sup>th</sup> century. In 1980, commercial paper was roughly 30 percent as large as M1, an aggregate measure of the money stock (consisting of currency outside of the U.S. Treasury, Federal Reserve Banks, and bank vaults, demand deposits, and other checkable deposits) while in 2007 commercial paper was 60 percent larger than M1.<sup>10</sup>

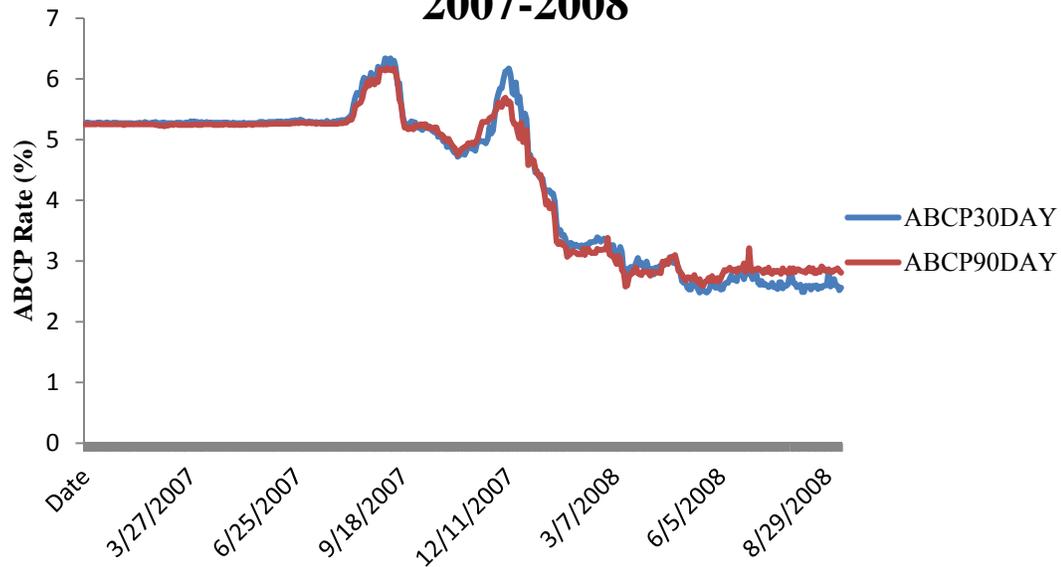
The financial crisis was largely precipitated by the deterioration of these markets as sources for funding for commercial and investment banks. In 2007, suspicions regarding the quality of the U.S. mortgage market and mortgage related structured products led to increasing difficulty among banks to finance their operations by pledging ABSs as collateral in repo or commercial paper markets. The realization among potential lenders that various mortgage related financial products contained non-negligible default risk in turn caused investors to become more wary about accepting these products as collateral. Since these securities were relatively opaque, as investors were generally unaware of the specific loans comprising a given ABS, when it became clear that some of these products would lose value, lenders became hesitant to accept all ABSs as collateral since it was unclear whether a given security was likely to default.

As concerns regarding subprime mortgages heightened toward the end of 2007, the amount of outstanding asset-backed commercial paper plummeted and balance sheets of commercial banks expanded. Mortgages and other loans that would have once been securitized and sold to investors or used as collateral had to be held on balance sheets. The effects of concerns regarding subprime mortgages can be seen through increased interest rates in asset-backed commercial paper markets and through higher repo haircuts.

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<sup>10</sup> The Federal Reserve's Commercial Paper Funding Facility, in FRBNY Economic Policy Review, page 26

## Asset-Backed Commercial Paper Rates 2007-2008



### 2.2 The Creation of Liquidity Facilities by the Federal Reserve

Increased pressures in money markets were of great concern to the Federal Reserve. As a result of the spikes in LIBOR rates during August of 2007, the Federal Reserve Board of Governors enacted various policies to improve liquidity conditions. On August 17<sup>th</sup>, 2007, the Federal Open Market Committee lowered the primary credit rate at its discount window facility by 50 basis points, to decrease the spread between the discount rate and the target federal funds rate. The FOMC also extended the term of loans available at the discount window to 30 days. One of the issues the Federal Reserve grappled with in its attempt to stabilize money markets was the stigma associated with discount window borrowing. In turbulent economic conditions banks may fear that borrowing from the Federal Reserve's discount windows will be seen as a sign of weakness by other financial institutions and by potential lenders or investors. As a result, while it may be beneficial to the financial system as a whole for banks facing funding pressures

to borrow from the discount window, individual banks may refrain from borrowing to avoid signaling financial weakness.

The Federal Reserve sought to remove the stigma associated with discount window borrowing. On August 22<sup>nd</sup>, the Federal Reserve announced that it had reached a deal with four large banks to borrow \$500 million each from the discount window. The New York Times reported that the “coordinated moves” by the banks, which included Citigroup, Wachovia, Bank of America, and JPMorgan “were seen as largely symbolic, aimed at removing the stigma of borrowing from the discount window, which is regarded as a last resort for financial institutions. All four banks can borrow money more cheaply elsewhere, and all said they had ‘substantial liquidity.’”<sup>11</sup> Finally, the Fed also sought to soften the adverse economic effects associated with decreasing liquidity in money markets by lowering the target federal funds rate several times throughout the year. The FOMC’s federal funds rate cuts in September, October, and December of 2007 sent the target rate from 5-1/4% in September to 4-1/4% in December.

Despite these efforts, the money market remained under stress throughout the year, spiking once again in late November. As the Federal Reserve’s conventional policy responses failed to yield sustained improvements in interbank markets, the Fed introduced several new facilities in 2007 and 2008 in order to bring increased liquidity to financial markets and to ease concerns among banks regarding their abilities to raise funds for periods longer than overnight.

The Federal Reserve introduced the first of these programs, the Term Auction Facility (TAF), along with reciprocal currency arrangements (also referred to as swap lines), in December 2007 (See figure 2). The TAF was an alternative mechanism to the discount window

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<sup>11</sup> Dash, Eric, New York Times, August 23<sup>rd</sup>, 2007

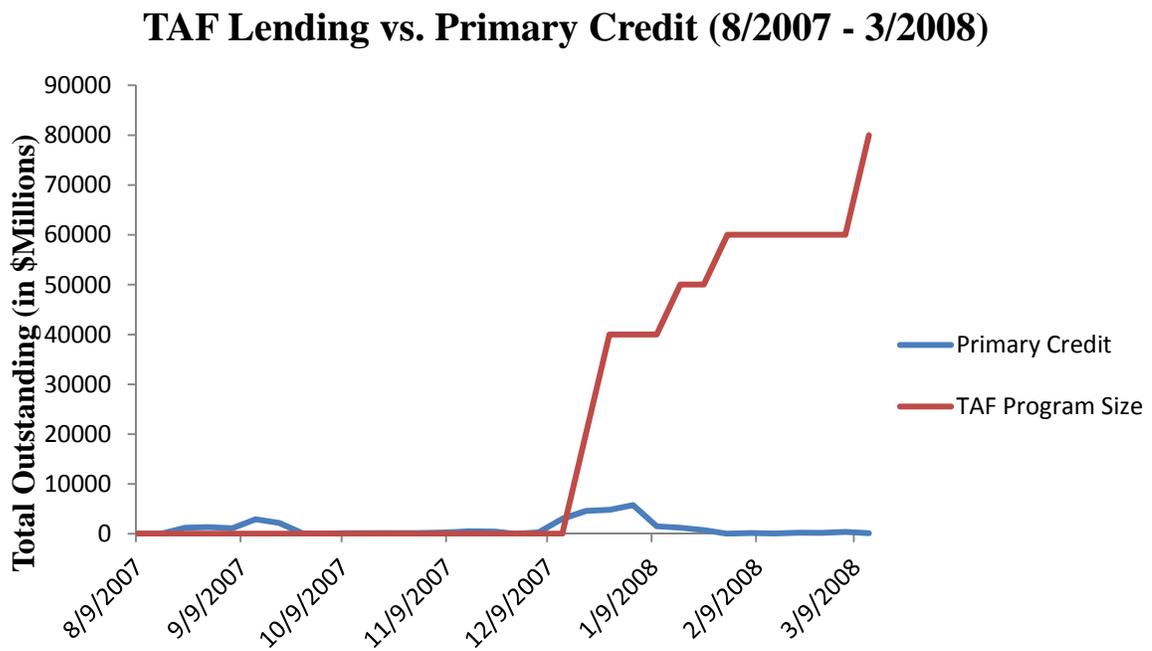
to inject cash liquidity into money markets. Observing the reluctance of many banks, despite heightened concerns about the availability of funds, to borrow from the discount window, the Fed designed the TAF to push money into financial markets instead of relying on banks to take initiative when funding was needed. In the TAF program, the Fed held a series of auctions where participating banks could bid for funds by submitting the desired size of the loan they would bid on as well as an interest rate they would be willing to pay for their desired loan.<sup>12</sup> By announcing that it would inject a certain amount of liquidity into financial markets regardless of the demand for funds by individual banks, the Fed hoped that it could circumvent the issue of discount window stigma by encouraging banks to take part in auctions that could potentially provide cheaper credit than they could get elsewhere. The Fed hoped that the knowledge that funds would be injected into the banking system, irrespective of solicitation of these funds by any specific borrower, would help relieve the stigma associated with borrowing from the Fed.

The TAF was expanded several times throughout the life of the program. After its initial announcement on December 12<sup>th</sup>, 2007, in which the Fed announced that TAF loans would reach \$40 billion outstanding, the Fed expanded the program to \$60 billion on January 4<sup>th</sup>, 2008, to \$100 billion on March 7<sup>th</sup>, 2008, and to \$150 billion on May 2<sup>nd</sup>, 2008. After the collapse of Lehman brothers in September 2008, the TAF was expanded again, as maturities of loans offered through the TAF program were extended (loans were ultimately offered for terms of 84 days, an increase from the 28 day loans offered when the program began) and by increasing the amount offered at each auction to \$150 billion, from the \$75 billion offered in the summer of 2008. One

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<sup>12</sup> Before each auction, the Fed announced the amount it intended to lend as well as the minimum and maximum bid sizes and the minimum interest rates at which bids could be submitted. In allocating money through the TAF program, the Fed gave priority to the banks that submitted the highest interest rate bids, giving the full amount of desired loans to each of these bidders until all of its funds had been allocated. The interest rate submitted by the last bank to receive funds (the lowest interest rate bid for a bank receiving funds) was called the stop-out rate. At the completion of the auction, each of the banks that received funds would be charged the stop-out rate as their interest rate.

measure by which the TAF program was certainly a success was in its ability to introduce liquidity into the banking system at much higher levels than were achieved by the Fed's discount window facility. Auctions generally had many participants and almost all TAF auctions had bids exceeding the amount offered through the program (see chart below for a comparison between TAF loans and discount window loans, or primary credit).



Another program announced by the Fed on December 12<sup>th</sup>, 2007, to help relieve money market strains was the swap lines program.<sup>13</sup> With the initiation of the swap lines program, the Federal Reserve acknowledged that financial sector strains were international in scope and that the TAF, since it funneled money only to banks that operated within the United States, was insufficient to solve the problems facing international money markets. The collapse of asset-backed commercial paper markets was particularly detrimental to foreign banks. Foreign banks

<sup>13</sup> In contrast to the TAF, TSLF, and PDCF programs, the swap lines had been offered by the Fed prior to December, 2007. Swap lines had been extended occasionally to foreign central banks since the 1960's, including the period of money market disruptions that followed the terrorist attacks of September 11<sup>th</sup>, 2001.

often purchased structured finance assets containing loans on U.S. mortgages, which were denominated in dollars. Since foreign banks lacked the large dollar deposit bases typical of U.S. commercial banks, they were highly reliant on asset-backed commercial paper markets to fund their dollar denominated investment vehicles. Interbank loans were the other source of dollar funding for foreign banks, and as such, high LIBOR rates had a disproportionately negative impact on non-U.S. banks.<sup>14</sup>

The swap lines program sought to provide dollar funding to banks without substantial U.S. operations by channeling money through the European Central Bank (ECB) and the Swiss Bank. The swap lines allowed these banks to sell their currency to the Fed for dollars at the market exchange rate. After this transaction, foreign banks entered into agreements to repurchase their foreign currency at the same exchange rate at a predetermined future time, paying the Fed the same interest rate that it charged on its dollar lending facilities. By allowing the ECB and Swiss Bank to access dollar funding in this way, the Fed enabled these central banks to create and implement their own liquidity facilities, giving term funds denominated in dollars to banks operating within their jurisdictions.<sup>15</sup> Like the TAF, the swap lines program was also expanded several times throughout its existence. A total of \$24 billion was made available to the two central banks in the initial announcement of the program on December 12<sup>th</sup>, 2007. The program was then expanded on March 11<sup>th</sup>, May 2<sup>nd</sup>, and July 30<sup>th</sup> of 2008. After the Lehman crash the program was further expanded and the dollar swap lines were offered to additional central banks.

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<sup>14</sup> It should be noted that spikes in LIBOR rates during this period were often associated with increases in the spread between borrowing rates of foreign and U.S. banks in the LIBOR panel. The August 9<sup>th</sup> spike in LIBOR rates, for example, also saw a large increase in the spread between U.S. and foreign banks in the LIBOR panel.

<sup>15</sup> For example, the ECB initiated a program that offered 1 and 3 month loans to at the stop-out rate of the most recent TAF auction.

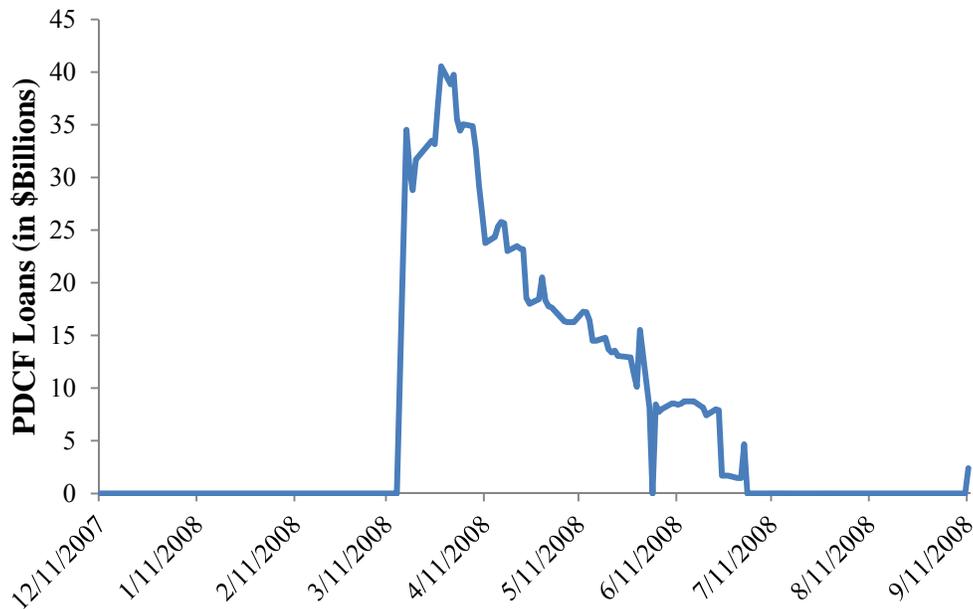
In March of 2008, liquidity concerns spread from commercial banks to investment banks. Money markets again faced turmoil as the large investment bank, Bear Stearns, neared default. In early March, LIBOR rates spiked and repo markets faced increasing strain. In the days surrounding the collapse of the Bear Stearns, the Fed introduced two new programs, called the Term Securities Lending Facility (TSLF) and the Primary Dealer Credit Facility, in order to improve financial conditions for investment banks.

The Term Securities Lending Facility, announced on March 11<sup>th</sup>, 2008, was an auction facility like the TAF. In the TSLF, banks could swap risky collateral, including agency mortgage backed securities, and investment grade debt securities, for treasury securities. During TSLF auctions, the Fed announced the amount it would auction and received bids from banks representing the fee that those banks would be willing to pay in order to swap a basket of approved collateral for treasury securities. Securities obtained in TSLF auctions were lent for periods of 28 days. After receiving treasuries from the Federal Reserve, investment banks could use the securities as collateral for borrowing money in repo markets. Because treasuries were less risky and less volatile than the asset-backed securities that banks used to secure funding through the TSLF program, banks using newly obtained treasuries to borrow in repo markets would face lower repo rates and haircuts than they would when pledging mortgage-backed securities as collateral.

Similarly, the Primary Dealer Credit Facility (PDCF) sought to provide an emergency liquidity backstop for investment banks. Much like the Federal Reserve's discount window, the PDCF allowed primary dealers, or banks that conduct open market operations with the Federal Reserve (in contrast to the commercial banks that may borrow money through the discount window), to borrow funds overnight by pledging a range of securities, including mortgage

backed securities and investment-grade tranches of derivative products, as collateral. In allowing banks to use the PDCF, the Fed imposed a haircut on the collateral posted by borrowers. The haircut imposed by the Fed was designed to make borrowing from the PDCF attractive only during times of abnormal financial stress, in order to encourage banks to borrow in private markets when such markets were operating soundly.

### **PDCF Loans Outstanding (2007-2008)**



It should be noted that the liquidity facilities established during the sample period analyzed in this paper did not change the Federal Reserve's overall monetary stance. That is, although the programs were geared toward improving the allocation of liquidity in the banking system by facilitating the transfer of funds from banks with excess liquidity to those that needed it, the Fed did not change its aggregate provision of liquidity unchanged, keeping the quantity of base money constant through the operation of these programs. In order to avoid changing the money supply through their facilities, and thus their overall policy stance, the Fed sterilized the

operation of the TAF, PDCF and Swap Lines programs by selling securities to offset the change in the money supply achieved through the operations of these facilities.<sup>16</sup>

While the Federal Reserve's liquidity facilities differed in their design and the in the specific markets and market participants they targeted, the facilities all represented attempts by the Fed to alleviate liquidity risk in money markets. During periods of financial stress, banks become less willing to lend to each other for various reasons. One reason is that lenders fear that potential borrowers may have bad loans or assets on their balance sheets and that these loans will make the borrower insolvent and unable to pay back its loan to a lender. While Federal Reserve programs may have indirectly affected bank balance sheets (for example by temporarily allowing banks to exchange mortgage-backed securities for treasuries), because the Fed does not control what banks invest in, Federal Reserve policies had little effect on this variety of default risk.

Another reason banks are more reluctant to lend to one another during periods of financial turmoil is that banks face increasingly uncertain funding pressures during moments of financial stress. Borrowers in repo markets may fear that repo investors will demand higher haircuts on certain types of collateral or stop lending against these types of collateral altogether. Banks may also fear that investors in money market mutual funds, which buy financial and asset-backed commercial paper, will flock to the safety of treasury securities and halt purchases of commercial paper. Fearing future funding pressures of these varieties, even banks with money to lend may choose to hoard their reserves or to lend only for very brief periods. By providing both investment and commercial banks with various sources of emergency funding, the Fed hoped to quell fears of funding strains in money markets. Federal Reserve facilities therefore work both

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<sup>16</sup> The TSLF did not need to be sterilized since it was purely an exchange of one type of security for another and therefore did not affect the money supply.

by making liquidity available to banks that need it, and by creating a regime that convinces banks with money to lend that if financial conditions deteriorate further in the future, the Fed will provide emergency assistance.

### **3.1 Literature Review**

There have been four recent papers that have informed my analysis of Federal Reserve Liquidity Facilities. McAndrews, Sarkar, and Wang (2008), examines the effect of TAF announcements on LIBOR-OIS swap rates. The authors run several regressions that look at the one-day change in the LIBOR-OIS spread as a function of Fed announcements, credit default swap rates of major financial institutions rates (a broad measure of credit risk) and a lag variable, measuring the previous day's level of LIBOR. The paper concludes that TAF announcements had a significant effect on LIBOR rates.

The authors take advantage of the fact that the TAF program was extended and expanded several times throughout the early life of the program (the sample period used in the paper goes only as far as April 2008) which naturally yields several days on which one might expect LIBOR-OIS rates to change more than normal. The authors construct a TAF dummy variable. The variable assumes a value of zero on days on which there was neither a significant announcement relating to the structure or duration of the TAF, nor an auction associated with the TAF facility. The TAF dummy receives a value of one on days during which TAF announcements or auctions occurred. The authors conclude that the TAF had a significant effect on LIBOR rates. The authors then run a regression of a less restrictive form, allowing TAF announcement days and auction days to have different coefficients. The paper finds that announcements have significant coefficients, while auctions do not.

Wu (2008) develops an affine term structure model in his analysis of LIBOR rates.<sup>17</sup> Wu looks at the effects of the TAF, the PDCF, and the TSLF on 1-month and 3-month LIBOR rates while controlling for systematic default risk by creating a variable that reflects a basket of credit default swaps. Next, Wu examines the effect of the TAF on credit risk, by regressing the credit default variable on a TAF dummy, and several state variables reflecting macroeconomic and financial market conditions. Wu finds that the TAF has no significant effect on systematic default risk. Finally, Wu regresses LIBOR rates on macroeconomic and financial control variables as well as dummies for the TAF and the TSLF in order to examine the total effects of Federal Reserve liquidity facilities on LIBOR rates. Wu finds that the TAF has a significant effect on LIBOR rates, but that the TSLF does not. Wu also notes that his model does not allow separate identification of the effects of the TSLF and the PDCF since the programs were started around the same time. Wu creates a dummy variable for each of these facilities. His equation does not look at LIBOR-OIS spreads in first difference form, but instead looks at the overall level of the LIBOR-OIS spread as a function of Fed policy dummy variables. His variables for the TAF, and PDCF and TSLF (grouped together), give the programs a value of zero on all days preceding their introduction, and a value of one on all days following their introduction. Wu's paper does not take advantage of program expansions or of other announcements related to these facilities and does not attempt to examine the separate effects of auctions and settlements.

Christensen, Rudebusch, and Lopez (2009), develops a six factor arbitrage-free affine model to construct a counterfactual path for the LIBOR rate in the absence of Federal Reserve liquidity facilities. Comparing the counterfactual to the observed LIBOR rate during the period of interest, the paper concludes that LIBOR was significantly lower than the counterfactual and that Fed facilities helped lower inter-bank borrowing rates.

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<sup>17</sup> Affine refers to models of the yield curve of a particular fixed income asset. These models impose a “no arbitrage” condition using cross equation restrictions and model bond yields as a linear combination of a constant term and some state vector. (Piazessi, 2010)

### 3.2 Data Sources

The data range from January 3<sup>rd</sup>, 2007, to September 11<sup>th</sup>, 2008<sup>18</sup>. The sample period is made up of all days on which 1-month and 3-month LIBOR were released. Days on which LIBOR rates were not released are not included in the sample, therefore all weekends and UK bank holidays are excluded even if changes in control variables occurred on those days. This approach generally does not cause problems since LIBOR rates are most significantly affected by financial conditions at the time LIBOR rates are released, rather than financial conditions of previous days.

The data come from a variety of sources. I use 1-month and 3-month LIBOR rates obtained from the Federal Reserve Economic Data collection of the St. Louis Fed, OIS rates of the same maturities from Haver analytics, commercial paper rates and maturities from the Federal Reserve Board of Governors data releases, and data on Treasury bonds from the U.S. Department of the Treasury website. Data on the sizes and announcement dates regarding liquidity facilities were obtained from the Federal Reserve Board of Governors website (See appendix 1 for a full discussion of data issues).<sup>19</sup>

### 3.3 Model, Variables, and Hypotheses

The basic models I estimate take the form

$$L_t = \alpha + \beta X_{t-1} + \gamma \text{FED}_{t-1} + u_t$$

Where L is 1-month or 3-month LIBOR-OIS spread at time t, X represents a vector of control variables at time t-1, and FED represents a collection of Federal Reserve policy variables at time t-1.

The choice of the LIBOR-OIS spread as the dependent variable was motivated by several factors. While some analyses of liquidity facilities have focused on other dependent variables, such as repo rates,

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<sup>18</sup> Data are collected from January, 2007 until September, 2008, however regressions in section 4 are run on different parts of the sample.

<sup>19</sup> The official Treasury yield curve data are from [www.treasury.gov/resource-center](http://www.treasury.gov/resource-center). The Federal Reserve data are from [www.federalreserve.gov/monetarypolicy](http://www.federalreserve.gov/monetarypolicy)

(Fleming, Hrungr, and Keane 2008) LIBOR-OIS rates have been used more frequently in the literature on liquidity facilities (McAndrews, Sarkar, and Wang 2008, Wu 2008, Taylor and Williams 2008). An analysis of Federal Reserve policy on repo rates may be difficult since repo transactions are conducted over the counter and data obtained on repo transactions are often incomplete. Repo is also conducted against various collateral types, and as such, there is not a singular repo rate. While repo rates may reflect both the credit risk of the borrower and the riskiness of the pledged collateral, the LIBOR-OIS spread is more reflective counterparty risk in the banking system (McAndrews, Sarkar, and Wang 2008 et al.)

By choosing the LIBOR-OIS spread, rather than simply the LIBOR rate as the dependent variable, the model controls for the expected future path of monetary policy. In the literature on LIBOR rates, LIBOR is believed to be composed of a risk-free rate, a credit risk premium, a liquidity premium, and a term premium (Bank of England 2008, et al.). Since I seek to analyze the effects of Federal Reserve policy on the systematic risk and liquidity conditions in the financial system, it is natural to subtract a measure of the risk-free rate when conducting this analysis. When subtracting the OIS, a gauge of the expected effective federal funds rate over a specific period, (either one or three months for the purposes of my analysis) the remaining value is equal to the credit and liquidity risk premiums embedded in the LIBOR rate.<sup>20</sup>

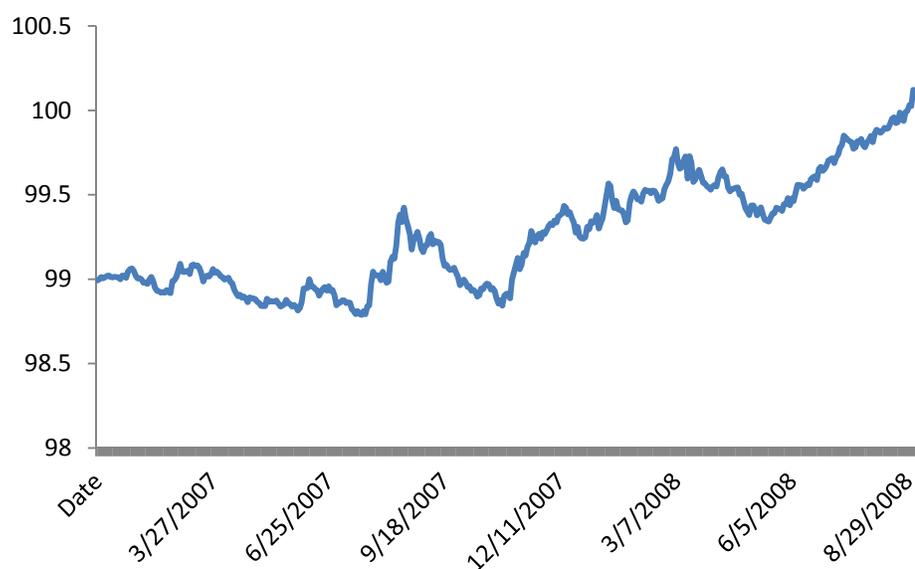
In choosing control variables, I am guided by the analysis in Wu (2008), which seeks to control for aggregate risk in financial markets and the macro economy. The control variables used in this analysis are also guided by an understanding of the specific factors that influenced money market conditions during the sample period.

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<sup>20</sup> The FOMC indirectly controls the Federal Funds rate, or the rates charged on overnight inter-bank loans of reserves held at the Fed. After the term of the loan expires, the Federal Reserve transfers the principal and interest of the loan back to the lending institution. Since the Federal Reserve is an intermediary in these loans, such loans are considered exceptionally safe. In contrast, the LIBOR rate measures interest rates charged on unsecured loans between banks for terms longer than overnight and therefore contain a risk premium above the federal funds rate.

To control for macroeconomic conditions, I use the components of the Goldman Sachs Financial Conditions Index (GSFCI), which contains the federal funds rate, the 5-year and 10-year treasury note yields, the iBoxx domestic BBB non-financial 15+ year bond spread over the 10-year T-note yield, the Goldman Sachs trade-weighted dollar index, the ratio of the S&P 500 to a 10-year average of earnings per share, and the Radar Logic daily house price index (Hatzius, Stehn, 2012).<sup>21</sup> The construction of the GSFCI is guided by FRB/US, the Federal Reserve’s econometric model of the U.S. economy. The index is constructed so that an increase in the value of the index illustrates tighter financial conditions. A positive shock of 100 basis points predicts a 1-1/2% decrease in GDP growth over the course of the year.

### Financial Stress (Measured by GSFCI)

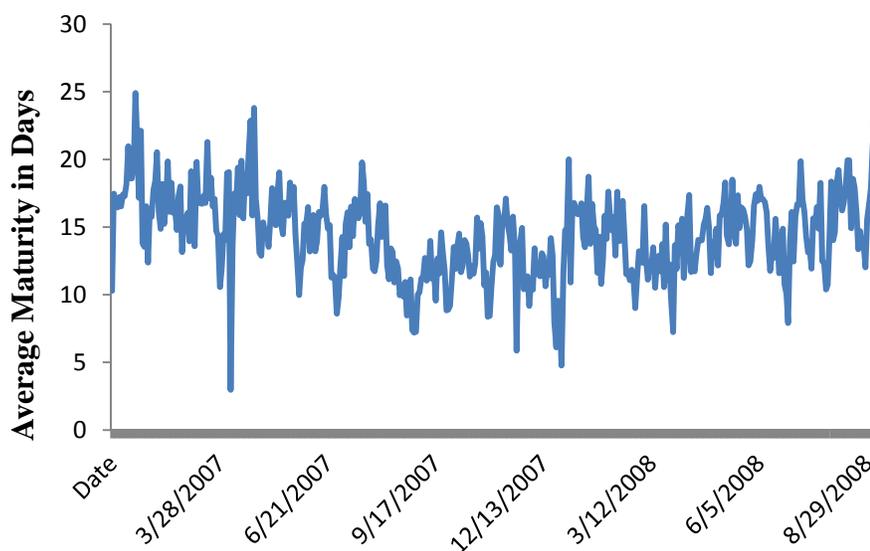


In addition to the Goldman Sachs financial conditions index, I use two variables related to the commercial paper market. These variables are the interest rates on asset-backed commercial paper of the same maturity as the LIBOR-OIS variable (denoted as ABCP in regression tables), and the average maturity of asset-backed commercial paper issuances (CPMATURITY). The variables are meant to

<sup>21</sup> The GSFCI also contains the TED spread. This spread was removed from the index in constructing the GSFCI variable used in regression analyses because the TED-spread is calculated as the difference between the 3-month LIBOR and the 3-month Treasury bill.

capture the liquidity strains facing banks as a result of deteriorating conditions in money markets resulting from unwillingness among lenders to accept certain collateral. The ABCP variable captures these liquidity strains straightforwardly, since lenders demanded higher interest rates to compensate for increasingly risky collateral. However, the interest rate may not be a complete indicator of liquidity constraints in financial markets since lenders may simply refuse to lend against a certain type of collateral at any interest rate.<sup>22</sup> As such, liquidity strains in asset-backed commercial paper markets can be viewed through steadily decreasing amount of asset-backed commercial paper outstanding at a given time. Because data on total outstanding values of commercial paper are not publicly available, I use the maturity structure of commercial paper (CPMATURITY) instead. A measure of the average maturity of commercial paper accounts for the increasing refusal of commercial paper lenders to lend for periods longer than overnight and to roll over existing long-term commercial paper. The shortening of average ABCP maturity is indicative of the pressures facing those markets in late 2007 and 2008.

### Average Maturity of 30 Day Asset-Backed Commercial Paper 2007-2008



<sup>22</sup> If lenders believe, for example, that willingness to pay high interest rate is an indicator of default likelihood, lenders may be unwilling to lend at any interest rate to borrowers that pose a high level of credit risk.

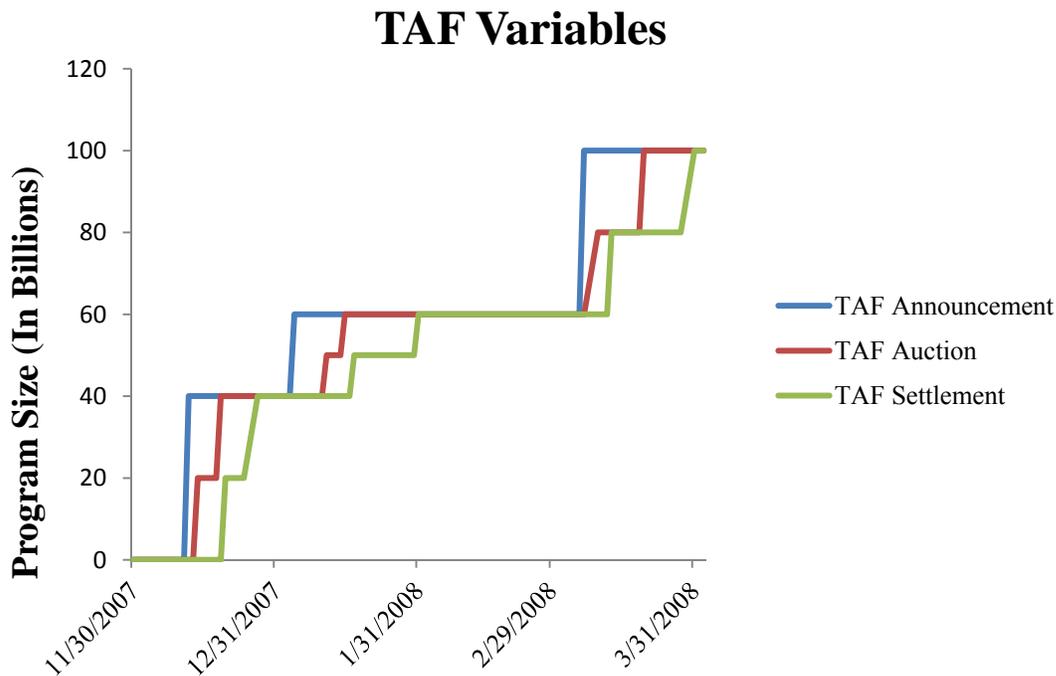
A final control variable of note is the volatility of treasury instruments (denoted as VOL in regression tables). The variable is calculated as the standard deviation of the previous four observations of treasury yields of the same maturity as the dependent variable.<sup>23</sup> This variable accounts for the level of economic uncertainty as well as for repo market conditions. As volatility of potential collateral in repo transactions increases, repo haircuts rise because the riskiness of assets increase as their returns become more volatile. Because treasury instruments were seen as the lowest risk repo collateral, increased risk of treasuries would likely signal stress in repo markets. Treasury volatility also accounts for economic uncertainty. Since treasury yields are driven largely by predictions of future monetary policy, volatile treasury instruments mean that there is high uncertainty regarding whether the future economic landscape will be inflationary, generating high future treasury yields, or whether there will be high unemployment and potentially loose future monetary policy.

The Federal Reserve policy variables take the form either of dummy variables or of quantitative step functions (appropriately differenced). When constructed as dummies, Federal Reserve variables take a value of one beginning on a day of interest. For example, when assessing whether the announcement of the TAF began a new regime in money markets, the TAF announcement variable takes a value of one on December 12<sup>th</sup>, the day the program was announced. When constructed in quantitative form, Federal Reserve policy variables take values related to the size of the program on a specific day. For example, since it was announced on December 12<sup>th</sup> that the TAF would conduct auctions such that \$40 billion of TAF loans would be outstanding at a given time, the TAF announcement variable assumes a value of 40 on December 12<sup>th</sup>.

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<sup>23</sup> Both the ABCP and VOL variables differ depending on whether the 1-month or 3-month LIBOR-OIS spread is used as the dependent variable. While it is likely that 1-month interest rates and volatilities are relevant in determining the 3-month LIBOR-OIS spread and vice versa, interest rates and volatilities of the same maturity structure are most relevant in determining a given spread. Omission of these variables introduces bias in coefficients of variables correlated with the omitted variable. Since treasury yields (and thus volatilities) of various maturities are highly correlated, the coefficient on VOL likely picks up the effects of volatilities of all treasury instruments (the same applies for ABCP rates). This effect is desired since it would be unrealistic to include volatilities of all possible treasury instruments as independent variables. Because the purpose of the paper is not to determine the exact effects of these specific instruments on LIBOR-OIS spreads, the bias introduced in the VOL and ABCP coefficients is not of particular concern.

Federal Reserve variables can be divided into three categories: announcement variables, auction variables, and settlement variables. Announcement variables assume their values on the days on which new liquidity facilities are announced or on days in which the expansion of facilities are announced. Auction variables change on days in which the terms of a specific auction are announced.<sup>24</sup> Finally, settlement variables change on days in which programs actually give out funds or assets to commercial or investment banks.



I have several hypotheses regarding the coefficients on variables in my regressions. I hypothesize that coefficients on commercial paper rates, treasury volatility, and on the GSCFI will be positive, since increases in volatility, interest rates in commercial paper markets and aggregate financial risk (as defined by a positive shock to the GSFCE) are indicators of financial stress, which is measured in the LIBOR-OIS spread. I believe that the coefficient on the CPMATURITY variable will be negative, since a shortening

<sup>24</sup> This category of variables is relevant only for the TAF and TSLF variables, since these are the two auction facilities. On the day of TAF auctions and TSLF auctions, the Fed announced the amount of money auctioned, the minimum and maximum bid sizes for each auction, and the minimum interest rate (in the case of the TAF) or the minimum fee (in the case of the TSLF) that would be considered.

of commercial paper maturity indicates that lenders are unwilling to loan funds over the long-term because of credit and liquidity risk. Finally, I hypothesize that Federal Reserve policy variables will have negative coefficients, since Federal Reserve facilities were designed to alleviate financial strain in money markets.

I do not have strong theoretical assumptions regarding the relative magnitudes of coefficients on the announcement, auction, and settlement variables of Federal Reserve facilities. The notion of efficient markets suggests that information regarding the future provision of liquidity should have immediate effects on interest rates, even before liquidity is introduced into the banking system. As such, announcements establishing or expanding Federal Reserve liquidity facilities should push down LIBOR-OIS spreads. In the case of the TAF and TSLF programs, new information regarding the structure of auctions is made on the day of each auction, and as such, auction days may be associated with decreasing LIBOR-OIS spreads if the resolution of uncertainty regarding specific auction details increases the confidence of lenders. Finally, if banks are severely liquidity constrained, knowledge of future liquidity may not be a perfect substitute for immediate liquidity. If banks do not have enough liquidity to loan at a given moment, the knowledge that they may receive funds in the future may not be sufficient in convincing them to make loans in the present. As such, the actual receipt of funds may be as important as announcements or auctions in driving down LIBOR rates. As such, I believe that coefficients on each of these three categories of variables will be negative and that the magnitudes of these coefficients will be suggestive of the overall financial environment and the extent to which banks are liquidity constrained. If few banks face imminent liquidity failure, then we would expect coefficients on the settlement variables to be insignificant.

#### 4. Regression Models and Results

Recent literature on liquidity facilities differs in the authors' choices of regression specifications. There have been disagreements regarding the appropriate sample length, the choice of dependent variable and the construction of Federal Reserve policy variables.

Wu (2008) uses a sample that begins on the first trading day of 2007 and extends through April, 2008. A potential weakness in choosing to begin the sample in early 2007 is that the LIBOR-OIS spread prior to the August 9<sup>th</sup> spike was low and stable while the spread after that day tended to be higher and more volatile. If the change in LIBOR rates after August 9<sup>th</sup> represents a structural change, this change may be exhibited by a change in coefficients on variables driving the LIBOR-OIS spread. One hypothesis is that LIBOR rates were nearly equal to OIS rates prior to August, 2007, and changes in the spread related to mostly small idiosyncratic fluctuations in the supply and demand for inter-bank loans, while the August 9<sup>th</sup> announcement sparked fears amongst financial institutions, which prompted them to more closely examine credit and liquidity conditions in financial markets. To test for a structural change on August 9<sup>th</sup>, I perform a Chow test using the control variables from my sample, running a restricted regression using Wu's full sample and two unrestricted regressions (not reported) on the sub-sample prior to August 9<sup>th</sup> and the sub-sample following August 9<sup>th</sup>. The resulting F-Statistic from this test is 34.99, much higher than the 5% critical value of 2.266. I reject the null hypothesis that coefficients on control variables were the same before and after August 9<sup>th</sup>. My regressions therefore use samples that begin on that day.

On the choice of dependent variable, Wu (2008) argues that December 12<sup>th</sup>, 2007 should be thought of as a regime change in money markets on which the Federal Reserve committed to intervention in order to keep rates low and stable. Wu's regression tests whether Federal Reserve policy made the level of the LIBOR-OIS spread lower, *ceteris paribus*, than it was in the part of the sample preceding the introduction of Federal Reserve liquidity facilities. Wu therefore argues that the level of the LIBOR-OIS

spread should be used as the dependent variable with a liquidity facilities dummy variable defined as equaling zero on days prior to the December 12<sup>th</sup> establishment of liquidity facilities and one on all following days.

McAndrews, Sarkar, and Wang (2008) argue that the 1<sup>st</sup> difference, or one day change, of the LIBOR-OIS variable is the proper dependent variable. The authors argue that Wu's specification adopts the assumption that the effects of Federal Reserve liquidity facilities are permanent throughout the sample, which they view as an excessively restrictive assumption. McAndrews, Sarkar, and Wang also argue that the LIBOR-OIS spread is non-stationary during the sample period. The presence of a unit root would invalidate statistics obtained using the level of the LIBOR-OIS spread as the dependent variable.

To consider this critique, I perform an augmented Dickey-Fuller test using the 1-month and 3-month LIBOR-OIS spreads from the 2007 sample period. McAndrews, Sarkar, and Wang believe the LIBOR-OIS spread is characterized by a unit root process. However, my analysis suggests that LIBOR-OIS spreads are stationary with a structural break on August 9<sup>th</sup>, 2007. If this is the case, the LIBOR-OIS spread beginning on August 9<sup>th</sup> should be a stationary time series. A Dickey-Fuller which uses August 7<sup>th</sup>, 2007 as the beginning of the sample period rejects the null of a unit root at the 5% level for the 1-month LIBOR-OIS spread and at the 1% level for the 3-month spread. However, while the Dickey-Fuller test rejects the unit root testing for serial correlation show that errors may be persistent. A Breusch-Godfrey test for serial correlation strongly rejects the null hypothesis of no serial correlation, returning a chi-square test statistic of 350.11, with an associated p-value of zero, to four digits. In light of the presence of serial correlation, I perform a Prais-Winsten iterative procedure to estimate  $\rho$ , the coefficient relating residuals at time  $t$  to those at time  $t-1$ . The estimate of  $\rho$  obtained from this procedure is .9833, which is not significantly different from 1. As such, LIBOR-OIS spreads likely are characterized by some type of unit root process, and as such, in all regressions following regression (1) I adopt the choice of dependent variable used in McAndrews, Sarkar, and Wang (2008), and use the first

difference of the LIBOR-OIS spread as the dependent variable as well as differenced forms of the control and Fed policy variables.

Wu (2008) treats the initial Federal Reserve announcement regarding liquidity facilities, on December 12<sup>th</sup>, 2007, as the beginning of a new regime in money markets. In my first regression I attempt to replicate Wu's results using the sample beginning in August, 2007, and the control variables chosen for my regressions. It is useful to assess the effectiveness on this regime change on the sample period prior to the establishment of the PDCF and TSLF since the announcements of these programs may have again altered financial conditions. I adopt a regression in the following form

$$L_t = \alpha + \beta X_{t-1} + \gamma \text{CBANKANNOUNCE}_{t-1} + u_t \quad (1)$$

Where  $L$  is the 1-month or 3-month LIBOR-OIS rate on day  $t$ ,  $X$  represents a vector of control variables at  $t-1$ , and  $\text{CBANKANNOUNCE}$  is a dummy variable that takes a value of zero on days prior to the December 12<sup>th</sup> announcement by the Fed that it would create liquidity facilities, and a value of one on all days following the announcement.<sup>25</sup>

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<sup>25</sup> Variables other than the LIBOR-OIS spread enter the regression with a lag because the LIBOR rate is announced daily at 11AM in London, or 6AM EST. The control variables are based on values at the time of market closing in the United States. Fed variables varied in their announcement times but did not take place prior to the 6AM LIBOR announcements on a given day. Therefore, Fed actions and control variables are assumed to affect LIBOR rates on the following day. The 1-month and 3-month OIS rates used to calculate LIBOR-OIS are also taken from period  $t-1$ .

Table 1

N=148	LIBOR-OIS 1-Month		LIBOR-OIS 3-Month	
	Coefficient	t-statistic	Coefficient	t-statistic
<b>GSFCI</b>	69.64***	5.4	39.86***	2.97
<b>ABCP</b>	24.46***	10.24	15.17***	6.01
<b>VOL</b>	-43.86***	-3.04	-64.3***	-3.02
<b>CPMATURITY</b>	-1.71**	-2.64	-1.54***	-2.42
<b>CBANKANNOUNCE</b>	-6.79	-1.05	-2.00	-0.33
<b>constant</b>	-6930.4	-5.42	-3924.70	-2.95
<b>R-squared</b>	0.64		0.45	

t-statistics are based on Newey-West Standard errors. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels respectively for all regressions

The results from this regression largely fall in line with hypotheses regarding the effects of financial variables on LIBOR-OIS spreads (table 1). The coefficients on the GSFCI and ABCP variables indicate that increased financial stress (indicated by a positive shock to the GSFCI) and elevated borrowing rates in asset-backed commercial paper markets are associated with elevated spreads for 1-month and 3-month LIBOR-OIS spreads. Both coefficients are significant at the 99% level of significance and results indicate that an increase in commercial paper borrowing rates of 100 basis points leads to a 24.4 basis point increase in LIBOR-OIS spreads, suggesting that rates in asset-backed commercial paper markets are somewhat more volatile than rates in inter-bank borrowing markets. As expected, a decrease in the average maturity of asset-backed commercial paper is associated with increases in LIBOR-OIS spreads.<sup>26</sup>

<sup>26</sup> One puzzling result is the coefficient on volatility, which is negative and significant at a 99% confidence level, since theory indicates that LIBOR rates should rise with increased economic uncertainty. The results in Wu (2008) also indicate that treasury volatility should be significantly positively associated with the LIBOR-OIS spread. Wu (2008) uses the Merrill Lynch MOVE index which is calculated as a weighted average of U.S. treasury securities of different maturities, while my volatility variable uses implied volatility on 1-month treasury instruments. The likely reason for this discrepancy is the difference in sample periods between the two papers. Treasury volatility sharply increased on August 9<sup>th</sup>, 2007, along with LIBOR-OIS increases. A regression using this sample period (not reported) confirms that treasury volatility has a significant positive coefficient over this period. These results indicate that treasury volatility was not a significant driver of changes in interest rates after August 9<sup>th</sup>.

The coefficient on the Federal Reserve dummy variable also fits with theory. The coefficient on the variable is negative and is of a feasible magnitude. It can be interpreted to mean that the spread between the 1-month LIBOR rate and the 1-month OIS rate was 6.7 basis points lower, during the sample period following the announcement of the facilities, than it would have been in the absence of these facilities. Similarly, the coefficient on the CBANKANNOUNCE in the regression using the 3-month LIBOR-OIS spread as the dependent variable suggests that the existence of the TAF and swap lines programs made the 3-month spread 2 basis points lower than it would have been in the absence of these programs. These effects would have seemed large in period prior to August 9<sup>th</sup>, 2007, when the average LIBOR-OIS spread was 7 basis points and the standard deviation of the spread was less than one basis point. However, after August 9<sup>th</sup>, the standard deviation of the 1-month LIBOR-OIS spread was 25.1 basis points, indicating that the effect of liquidity facilities was small relative to the typical fluctuation of the spread during this period. While the coefficient on the liquidity facilities dummy variable is negative, it is not significant at a conventional confidence level. This may be because the effects of liquidity facilities were not permanent throughout the sample period.<sup>27</sup>

My next regression attempts to look at the effects of the TAF and swap lines programs during the sample period prior to the establishment of the TSLF and PDCF. Because the PDCF and TSLF were created during a period of renewed financial stress, in the wake of the failure of Bear Stearns, it may be that the effects of the TAF and Swap Lines programs diminished as the primary locus of financial concern became investment, rather than commercial, banks. The second regression I estimate therefore looks at the period from August 9<sup>th</sup>, 2008, until March 7<sup>th</sup>, 2008, the trading day immediately prior to the establishment of the TSLF. The equation takes the form

$$\Delta L_t = \alpha + \beta \Delta X_{t-1} + \gamma_1 \Delta \text{SWAPANNOUNCE}_{t-1} + \gamma_2 \Delta \text{TAFTOTAL}_{t-1} + u_t \quad (2)$$

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<sup>27</sup> This criticism of Wu's approach is noted in McAndrews, Sarkar, and Wang (2008).

where all variables are expressed in first difference form.<sup>28</sup> SWAPANNOUNCE represents the combined amount of dollar funding offered to the Swiss Bank and European Central Bank at time t-1 and TAFTOTAL represents the amount of liquidity announced, auctioned, or settled at time t-1.<sup>29</sup>

Table 2

N= 148	$\Delta$ LIBOR OIS 1-Month		$\Delta$ LIBOR-OIS 3 Month	
	Coefficient	t-statistic	Coefficient	t-statistic
$\Delta$ GSFCI	34.82**	2.07	50.78**	3.65
$\Delta$ ABCP	6.94	1.19	3.47	0.62
$\Delta$ CPMATURITY	-1.73	-1.27	-2.74**	-2.43
$\Delta$ VOL	-15.26*	-1.76	-25.78**	-2.07
$\Delta$ TAFTOTAL	-0.34**	-2.01	-0.28*	-1.95
$\Delta$ SWAPANNOUNCE	0.216	0.50	0.17	0.48
constant	0.633	0.93	0.52	0.94
R-squared	0.099		0.160	

$\Delta$  represents data in first difference form

The TAFTOTAL coefficient in the regression using the 1-month LIBOR-OIS spread as a dependent variable is negative and significant at a 5% confidence level, suggesting that Federal Reserve actions related to the TAF lowered LIBOR-OIS spreads during this period (table 2). Meanwhile, the TAFTOTAL coefficient in the 3-month LIBOR-OIS regression was negative and only significant at the 10% level. We can estimate the total effect of the Fed's establishment of the TAF. Since the TAFTOTAL

<sup>28</sup> The CP maturity variable is smoothed in differenced regressions since it is highly volatile. The CP maturity variable in these regressions is defined as the first difference of the 1-week moving average of commercial paper maturity.

<sup>29</sup> Since the three TAF related actions are given the same coefficient in this specification, the coefficient should be interpreted as the effect of an announcement, auction, or settlement of one billion dollars on the LIBOR-OIS spread. This is not the most natural specification for a Federal Reserve policy variable, since it is somewhat awkward to add the effects of announcements, auctions and settlements when they are part of the same process. Nonetheless, it is not unreasonable to assume that the effects of Federal Reserve policy relating to each action are related to the amount of liquidity offered by the Fed. A regression estimated with TAF events defined as a dummy (not reported) did not fit the data as well (defined in terms of the values of the coefficient's t-statistic and the regression's R<sup>2</sup> value) as the regression using a quantitative form of the variable.

variable restricts announcements, auctions, and settlements in liquidity facilities to the same coefficient, the initial \$40 billion program establishment would be estimated to have lowered the 1-month LIBOR-OIS spread by 40.8 basis points and the 3-Month LIBOR-OIS spread by 33.6 basis points.<sup>30</sup> The coefficient on the swap lines variable in this regression is positive and insignificant. This is likely because in the part of the sample prior to the establishment of the TSLF, only one announcement was made regarding the swap lines program, which occurred on December 12<sup>th</sup>, the same day the initial TAF announcement was made. The single non-zero observation for the Swap Lines in this period makes estimation of its effect difficult.

While the above regression allows the identification of a significant effect of the TAF program, the specification of this regression is highly restrictive in the sense that it allows only one effect from TAF events when TAF announcements, auctions, and settlements may each have a differential impact on the LIBOR-OIS spread. I therefore estimate an unrestricted regression in the form

$$L_t = \alpha + \beta \Delta X_{t-1} + \gamma_1 \Delta \text{SWAPANNOUNCE}_{t-1} + \gamma_2 \Delta \text{TAFANNOUNCE}_{t-1} + \gamma_3 \Delta \text{TAFAUCTION}_{t-1} + \gamma_4 \Delta \text{TAFSETTLE}_{t-1} + u_t \quad (3)$$

Where the variables are defined in the same way as in equation (2) and where TAFANNOUNCE, TAFAUCTION, and TAFSETTLE represent the announcement, auction, and settlement components of the TAF program, respectively.

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<sup>30</sup> The calculation is  $(40) * (-.34) * (3)$ , or the amount of liquidity (in billions) times the coefficient times the number of operations (including announcement, auction, and settlement.)

Table 3

N= 148	$\Delta$ LIBOR-OIS 1-Month		$\Delta$ LIBOR-OIS 3-Month	
	Coefficient	t-statistic	Coefficient	t-statistic
$\Delta$ GSFCI	31.3*	1.84	49.6***	3.54
$\Delta$ ABCP	8.83	1.44	3.67	0.64
$\Delta$ CPMATURITY	-1.77	-1.3	-2.73**	-2.41
$\Delta$ VOL	-13.94	-1.6	-25.48**	-2.03
$\Delta$ TAFANNOUNCE	-0.11	-0.61	-0.06	-0.46
$\Delta$ TAFAUCTION	-0.17	-0.66	-0.25	-1.15
$\Delta$ TAFSETTLE	-0.56**	-2.16	-0.3	-1.4
$\Delta$ SWAPANNOUNCE	-0.17	-0.39	-0.18	-0.48
Constant	0.66	0.98	0.51	0.92
R-squared	0.108		0.157	

When coefficients for the components of these programs are divided in this way, the coefficients on the announcement, auction, and settlement variables are -.111, -.178, and -.565, respectively (table 3). These coefficients indicate that a TAF program expansion of \$40 billion lowers the LIBOR-OIS spread by 4.4 basis points through the announcement, by 7.1 basis points through the auction, and by 22.6 basis points through the settlement process, or by actually injecting liquidity into the banking system. The total effect of the TAF program in the period prior to the Bear Stearns related market turmoil can be estimated as  $\gamma_2 \Sigma \text{TAFANNOUNCE} + \gamma_3 \Sigma \text{TAFAUCTION} + \gamma_4 \Sigma \text{TAFSETTLE}$ , which yields an estimate of 59.2 basis points. The effect of the Swap Lines program (which had only one announcement) is estimated as 4.3 basis points. However, while TAF auctions, announcements, and settlements and the swap lines program are all estimated to lower the LIBOR-OIS spread, only the coefficient on the TAF settlement variable is significant at the 5% level. The F-statistic testing the null hypothesis that the liquidity facilities, jointly, had no effect on the LIBOR-OIS spread, is 1.63 and is not sufficient to reject the null hypothesis at a 95% confidence level.

In the regression on the 3-month LIBOR-OIS spread, none of the coefficients on the TAF variables are significant at the 10% level. As in the regression using the 1-month LIBOR-OIS spread as a

dependent variable, the coefficients on the TAF announcement, auction and settlement variables are negative. As in the 1-month LIBOR-OIS regression, the settlement variable is estimated to have had the greatest impact on lowering LIBOR-OIS spreads, with a coefficient of -0.3 basis points per billion dollars, suggesting that \$40 billion of liquidity through the TAF program would have lowered LIBOR-OIS rates by 12 basis points. After the settlement coefficient, TAF auctions appeared to be the next most effective, followed by announcements. This contrasts with the findings in McAndrews, Sarkar, and Wang (2008) which suggest that announcements were more effective than auctions in relieving strains in money markets.

Next, I examine the entire sample period in order to address several questions related to Federal Reserve liquidity facilities. One question is whether announcements and provision of liquidity by the Fed in general were successful in lowering LIBOR-OIS spreads throughout the sample period. To answer this question I regress the 1-month and 3-month LIBOR-OIS spreads on the controls and a variable that captures the aggregate liquidity provided by the Federal Reserve (taking a quantitative form only on days on which commercial and investment banks actually received funds from the Fed), and a dummy variable that takes a value of one on any day the Fed made an announcement establishing or expanding one of its liquidity facilities. The regression takes the form

$$L_t = \alpha + \beta \Delta X_{t-1} + \gamma_1 \Delta \text{FEDANNOUNCE}_{t-1} + \gamma_2 \Delta \text{FEDSETTLE}_{t-1} + u_t \quad (4)$$

Where all variables are in first difference form and FEDANNOUNCE is the announcement dummy variable and FEDSETTLE is the variable that captures aggregate liquidity.<sup>31</sup>

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<sup>31</sup> The announcement variable here can only take the value of 0 or 1 because the PDCF was a standing facility rather than an auction facility and therefore didn't offer a set amount of funds. Combining announcements related to the

Table 4

<b>N=129</b>	<b>ΔLIBOR-OIS 1-Month</b>		<b>ΔLIBOR-OIS 3-Month</b>	
	Coefficient	t-statistic	Coefficient	t-statistic
<b>ΔGSFCI</b>	8.00	0.77	19.81**	2.18
<b>ΔABCP</b>	10.58***	2.74	7.06*	1.86
<b>ΔVOL</b>	-8.95	-1.54	-8.98	-1.04
<b>ΔCPMATURITY</b>	-0.76	-0.98	-1.12*	-1.66
<b>ΔFEDANNOUNCE</b>	-2.42	-0.98	1.46	0.67
<b>ΔFEDSETTLE</b>	-1.50E-07	-0.04	-2.05E-06	-0.07
<b>constant</b>	0.31	0.77	0.23	0.68
<b>R-squared</b>	0.0462	0.0266		

The regression on the 1-month LIBOR-OIS spread estimates that both the announcement and settlement variable have negative coefficients, but neither coefficient is significant at the 5% or 10% level (table 4). Both coefficients are relatively small, as Fed announcements establishing or expanding liquidity facilities are estimated to have lowered LIBOR-OIS spreads by 2.4 basis points on average while the settlement variable suggests that Fed injections of liquidity through these facilities had almost no effect on LIBOR-OIS spreads. The regression performed on the 3-month LIBOR-OIS spread yields similar results, with the coefficient on the announcement variable becoming positive and insignificant while the coefficient on the settlement variable remains negative and insignificant.

The regression performed on the full sample period, when contrasted to those using only the part of the sample preceding the Bear Stearns failure, illustrates several important findings. When given a single coefficient, Federal Reserve liquidity facilities are estimated to have had no effect on LIBOR-OIS rates through the entire sample period. Because regressions (2) and (3) illustrate that the TAF program, in particular liquidity distributed on settlement days from TAF auctions, reduced LIBOR-OIS spreads during the early sample period, the results from regression (4) illustrate either that programs other than

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TAF and TSLF with the announcement establishing the PDCF requires collapsing the original TAF and TSLF quantitative variables into a dummy.

the TAF were not as effective in reducing LIBOR-OIS spreads, that liquidity facilities in general became less effective after the failure of Bear Stearns, or both.

To address this question, I turn to the final part of the sample period. I regress the 1-month and 3-month LIBOR-OIS spreads on controls and on the unrestricted set of Federal Reserve policy variables, including all auction, announcement, and settlement variables. This regression takes the form

$$\begin{aligned}
 L_t = & \alpha + \beta \Delta X_{t-1} + \gamma_1 \text{SWAPANNOUNCE}_{t-1} + \gamma_2 \Delta \text{TAFANNOUNCE}_{t-1} \\
 & + \gamma_3 \Delta \text{TAFAUCTION}_{t-1} + \gamma_4 \Delta \text{TAFSETTLE}_{t-1} + \gamma_5 \Delta \text{TSLFANNOUNCE}_{t-1} \\
 & + \gamma_6 \Delta \text{TLSFAUCTION}_{t-1} + \gamma_7 \Delta \text{TSLFSETTLE}_{t-1} \\
 & + \gamma_8 \Delta \text{PDCFANNOUNCE}_{t-1} + \gamma_9 \Delta \text{PDCFSETTLE}_{t-1} + u_t \quad (5)
 \end{aligned}$$

Where the controls remain the same as in previous regressions and the ANNOUNCE, AUCTION, and SETTLE variables represent the announcements, auctions, and settlements of the various Federal Reserve programs. The results of these regressions illustrate that the TAF program likely became less effective as funding concerns migrated to investment banks (table 5).

Table 5

N=129	$\Delta$ LIBOR-OIS 1-Month		$\Delta$ LIBOR-OIS 3-Month	
	coefficient	t-statistic	coefficient	t-statistic
$\Delta$ GSFCI	5.66	0.74	14.37**	2.17
$\Delta$ ABCP	10.82***	3.4	7.53**	2.45
$\Delta$ VOL	-8.51**	-1.83	-11.25	-1.59
$\Delta$ CPMATURITY	-0.506	-1.02	-0.71*	-1.67
$\Delta$ SWAPANNOUNCE	-0.026	-0.1	0.004	0.02
$\Delta$ TAFANNOUNCE	-0.081	-0.7	-0.03	-0.35
$\Delta$ TAFAUCTION	-0.065	-0.64	-0.14*	-1.67
$\Delta$ TAFSETTLE	-0.17*	-1.68	-0.14*	-1.65
$\Delta$ TSLFANNOUNCE	0.0017	0.06	0.011	0.43
$\Delta$ TSLFAUCTION	0.086	1.6	0.064	1.38
$\Delta$ TSLFSETTLE	-0.004	-0.09	-0.02	-0.6
$\Delta$ PDCFANNOUNCE	0.1018	0.02	19.89***	4.33
$\Delta$ PDCFSETTLE	0.0001	0.5	1.20E-04	0.47
constant	0.24	0.94	2.36E-01	1.04
R-squared	0.048		0.0693	

While the announcement, auction, and settlement coefficients remain negative throughout the latter part of the sample, none is significant at the 5% level and only the TAF settlement coefficient is significant at the 10% level. In the 3-month LIBOR-OIS regression, only the TAF auction variable is estimated to have a negative coefficient while none of the coefficients on the TAF variables is significant. Among the variables representing the other programs, only the TSLF settlement variable has the negative coefficient predicted prior to this study. This finding is consistent with Fleming, Hrungr, Keane (2008), which estimated the TSLF effect on repo rates, finding that TSLF operations had an impact on repo rates while the announcement of the facility did not.

Results from this regression may illustrate the ineffectiveness of liquidity facilities, rigidity in money markets, or faults in the design of the study. While the TAF appeared to lower bank borrowing rates early in the life of the program, it is possible that the Fed's later facilities did little to relieve strain in

money markets. As 2008 progressed, fears regarding the size and location of subprime-related risk grew, as did fears regarding structured financial products securitized in a similar way to subprime assets. While the Fed attempted to provide liquidity to financial markets, it could do little to diminish the counterparty risk associated with subprime loans without purchasing these assets directly from banks, an approach later adopted through the Fed's Troubled Asset Relief Program. If LIBOR rates were driven more by counterparty risk associated with fears regarding the quality of loans made by banks, than by liquidity concerns, Federal Reserve programs may have been poorly equipped to handle the strains emerging in money markets.

Another possible explanation of these results is that the TSLF and PDCF targeted repo markets and were less focused on inter-bank lending markets. An assumption underlying this study is that borrowing markets, especially for the large commercial banks whose borrowing behavior drives LIBOR rates, are largely substitutable, and that banks looking to borrow short term funds are willing to borrow from segments money markets whose borrowing rates are most favorable. If this assumption held, LIBOR and repo rates would be expected to move together and policies that eased borrowing conditions in repo markets would also lower rates in the market for inter-bank loans.

However, Gorton and Metrick (2009) note that repo markets were far more important to investment banks than to commercial banks and that commercial banks were less likely to use repo markets. If the two markets are not linked, Federal Reserve policy targeting repo markets may not have effects on LIBOR rates. The strong co-movement between LIBOR and asset-backed commercial paper rates however, illustrates that different segments of the money market are most likely linked to one another. Contrasting the coefficients and t-statistics on the ABCP variables in regressions 1-3 with the coefficient in regression 5, reveals that conditions in commercial paper markets became more important in determining LIBOR-OIS spreads as the sample period wore on, suggesting that financial problems during this period concerned the availability and were common to various segments of money markets.

A final explanation for these results is that the study's methodology contains various weaknesses. One potential weakness concerns an endogeneity problem reflected in the policy variables. While Federal Reserve policy variables may be relevant in the equation that determines LIBOR-OIS rates, these rates may in turn influence decisions by the Federal Reserve. If program announcements and expansions were influenced by conditions in inter-bank borrowing markets, Fed policy variables will be positively correlated with the error term in regressions, introducing bias, in the positive direction, to coefficient estimates. If this endogeneity problem was particularly pronounced during the period surrounding the failure of Bear Stearns, the effects of the TSLF and PDCF program would be particularly understated.

Another related problem with the study is that control variables did not adequately control for credit risk. While other studies discussing Federal Reserve liquidity facilities have used credit default swap rates for companies in the financial sector to control for counterparty risk, I do not use these rates both because they are determined in OTC markets and are not publicly available, and because the study attempted to control for credit risk using more economically descriptive variables. By leaving out a potentially relevant variable, the study may have introduced bias in coefficients on variables correlated with credit risk. Since the Fed likely expanded its facilities when credit risk was high, this omission may have also introduced bias, in the positive direction, in coefficients on Federal Reserve variables.

## **5. Conclusion**

This study examines the effects of Federal Reserve liquidity facilities on LIBOR-OIS spreads. I develop a reduced form model of LIBOR-OIS spreads based on daily time-series financial data and Federal Reserve policy variables relating to the size of Federal Reserve liquidity facilities. The study expands on work developed by Wu (2008), and McAndrews, Sarkar and Wang (2008), by expanding the list of liquidity facilities considered, by constructing Federal Reserve variables quantitatively, and by allowing Federal Reserve actions to affect LIBOR-OIS spreads on announcement, auction, and settlement days. This paper also identifies a superior sample period to those used in earlier works on liquidity

facilities, since LIBOR-OIS spreads faced structural change in August, 2007 and changed again when Bear Stearns was rescued in March, 2008. The results of this study indicate that the Term Auction Facility helped to relieve strains in money markets in early 2008 but that the benefits of the program largely disappeared as financial stress moved from commercial to investment banks. The results also indicate that the TSLF and PDCF were unable to significantly lower borrowing rates in money markets. The methodological approach faced various limitations, particularly the lack of control variables accounting for credit risk and the potential endogeneity problem regarding the announcement and expansion of Federal Reserve programs. The paper also identifies the difficulties associated with estimating structural models relating to financial variables, since model parameters are subject to change as the conditions and concerns facing market participants evolve. Nevertheless, much about the relative effectiveness of Federal Reserve programs can be observed through the simple OLS framework advanced in this paper.

## **Appendix 1: Issues with Data Construction**

When using time-series data on which not all variables are available on all days within the period, potential problems emerge. Since all weekends and UK bank holidays were removed from the sample (because LIBOR rates are not collected on those days) I had to decide how to include Federal Reserve announcements that occurred on those days. One such instance is the announcement of the PDCF, which took place on Saturday, March 16<sup>th</sup>, 2008. To deal with this issue, the observation documenting the announcement of this facility was moved to March 19<sup>th</sup>, to coincide with the first trading day following the actual announcement, since this is the earliest instance on which the PDCF announcement could have affected the LIBOR-OIS spread. Another day on which an issue arises is March 24<sup>th</sup>, 2008 during which money was withdrawn from the PDCF, but which was a bank holiday in the UK, meaning that LIBOR rates were not reported. Since PDCF loans are overnight, loans made on the 24<sup>th</sup> of March are not included in the sample period because they did not remain in the banking system for long enough to affect LIBOR rates.

There are also days in the sample on which LIBOR rates were calculated but on which other variables are not available because American markets are closed. OIS rates, treasury rates, commercial paper rates, and the GSFCI index all had days on which they did not assume new values but on which a LIBOR rate was calculated. On these days, the control variables are assigned the same value as they were on previous days. This assignment should not change conclusions made about data. It was unlikely, for example, that expectations of future federal funds rates changed significantly from day. While it is possible that conditions changed in some markets even on days in which no trading in those markets occurred, there is no reason to believe that this was a frequent occurrence or that failing to account for this phenomenon would bias the results in a particular way. I rerun regressions of the 1-month and 3-month LIBOR-OIS spreads on control variables using interpolations, (defined as averages of the two days surrounding a day for which data are missing) and find the results remain qualitatively the same with minimal changes in magnitude.

## **Appendix 2: Federal Reserve Announcements establishing Liquidity Facilities**

## TAF and Swap Lines:

“For immediate release

Today, the Bank of Canada, the Bank of England, the European Central Bank, the Federal Reserve, and the Swiss National Bank are announcing measures designed to address elevated pressures in short-term funding markets.

### Federal Reserve Actions

Actions taken by the Federal Reserve include the establishment of a temporary Term Auction Facility (approved by the Board of Governors of the Federal Reserve System) and the establishment of foreign exchange swap lines with the European Central Bank and the Swiss National Bank (approved by the Federal Open Market Committee).

Under the Term Auction Facility (TAF) program, the Federal Reserve will auction term funds to depository institutions against the wide variety of collateral that can be used to secure loans at the discount window. All depository institutions that are judged to be in generally sound financial condition by their local Reserve Bank and that are eligible to borrow under the primary credit discount window program will be eligible to participate in TAF auctions. All advances must be fully collateralized. By allowing the Federal Reserve to inject term funds through a broader range of counterparties and against a broader range of collateral than open market operations, this facility could help promote the efficient dissemination of liquidity when the unsecured interbank markets are under stress.

Each TAF auction will be for a fixed amount, with the rate determined by the auction process (subject to a minimum bid rate). The first TAF auction of \$20 billion is scheduled for Monday, December 17, with settlement on Thursday, December 20; this auction will provide 28-day term funds, maturing Thursday, January 17, 2008. The second auction of up to \$20 billion is scheduled for Thursday, December 20, with settlement on Thursday, December 27; this auction will provide 35-day funds, maturing Thursday, January 31, 2008. The third and fourth auctions will be held on January 14 and 28, with settlement on the following Thursdays. The amounts of those auctions will be determined in January. The Federal Reserve may conduct additional auctions in subsequent months, depending in part on evolving market conditions...

The Federal Open Market Committee has authorized temporary reciprocal currency arrangements (swap lines) with the European Central Bank (ECB) and the Swiss National Bank (SNB). These arrangements will provide dollars in amounts of up to \$20 billion and \$4 billion to the ECB and the SNB, respectively, for use in their jurisdictions. The FOMC approved these swap lines for a period of up to six months.”

TSLF:

*Release Date: March 11, 2008*

“For immediate release:

Since the coordinated actions taken in December 2007, the G-10 central banks have continued to work together closely and to consult regularly on liquidity pressures in funding markets. Pressures in some of these markets have recently increased again. We all continue to work together and will take appropriate steps to address those liquidity pressures.

To that end, today the Bank of Canada, the Bank of England, the European Central Bank, the Federal Reserve, and the Swiss National Bank are announcing specific measures...

The Federal Reserve announced today an expansion of its securities lending program. Under this new Term Securities Lending Facility (TSLF), the Federal Reserve will lend up to \$200 billion of Treasury securities to primary dealers secured for a term of 28 days (rather than overnight, as in the existing program) by a pledge of other securities, including federal agency debt, federal agency residential-mortgage-backed securities (MBS), and non-agency AAA/Aaa-rated private-label residential MBS. The TSLF is intended to promote liquidity in the financing markets for Treasury and other collateral and thus to foster the functioning of financial markets more generally. As is the case with the current securities lending program, securities will be made available through an auction process. Auctions will be held on a weekly basis, beginning on March 27, 2008. The Federal Reserve will consult with primary dealers on technical design features of the TSLF.

In addition, the Federal Open Market Committee has authorized increases in its existing temporary reciprocal currency arrangements (swap lines) with the European Central Bank (ECB) and the Swiss National Bank (SNB). These arrangements will now provide dollars in amounts of up to \$30 billion and \$6 billion to the ECB and the SNB, respectively, representing increases of \$10 billion and \$2 billion. The FOMC extended the term of these swap lines through September 30, 2008.

The actions announced today supplement the measures announced by the Federal Reserve on Friday to boost the size of the Term Auction Facility to \$100 billion and to undertake a series of term repurchase transactions that will cumulate to \$100 billion.”

PDCF:

*Release Date: March 16, 2008*

**For immediate release**

The Federal Reserve on Sunday announced two initiatives designed to bolster market liquidity and promote orderly market functioning. Liquid, well-functioning markets are essential for the promotion of economic growth.

First, the Federal Reserve Board voted unanimously to authorize the Federal Reserve Bank of New York to create a lending facility to improve the ability of primary dealers to provide financing to participants in securitization markets. This facility will be available for business on Monday, March 17. It will be in place for at least six months and may be extended as conditions warrant. Credit extended to primary dealers under this facility may be collateralized by a broad range of investment-grade debt securities. The interest rate charged on such credit will be the same as the primary credit rate, or discount rate, at the Federal Reserve Bank of New York.

Second, the Federal Reserve Board unanimously approved a request by the Federal Reserve Bank of New York to decrease the primary credit rate from 3-1/2 percent to 3-1/4 percent, effective immediately. This step lowers the spread of the primary credit rate over the Federal Open Market Committee's target federal funds rate to 1/4 percentage point. The Board also approved an increase in the maximum maturity of primary credit loans to 90 days from 30 days.

### **Appendix 3: Glossary of Terms**

**Basis Point:** One one-hundredth of a percentage point, often used in measures of market interest rates.

**Commercial Paper:** A promissory note from a borrower agreeing to repay a loan with interest at a certain date. Unsecured commercial paper is generally used by very highly rated borrowers (often financial institutions) while asset backed commercial paper is collateralized by financial assets and if the assets are of high quality, the credit rating of the borrower is less crucial than in the unsecured case.

**Counterparty Risk:** The risk that an entity taking the opposite side of a financial transaction will be unable to honor their commitment to make payments under the initially negotiated financial contract.

**Discount Window:** The Federal Reserve's primary emergency lending facility through which banks in generally sound financial condition can approach their regional Fed branch and obtain funds for a specified period, usually overnight, while pledging a basket of approved collateral.

**Haircut:** The spread between the value of securities pledged in a repo contract and the size of the loan. A borrower who has to pledge \$100 of securities for a \$90 loan faces a 10% haircut.

**LIBOR:** The London Inter-Bank Offered Rate. A rate set on every trading day by a survey of bankers in London who report to the British Bankers Association. The rate represents an estimate of the average interest rate a large financial institution would have to pay for an unsecured loan lasting for a specified time period.

**Liquidity:** A broad term generally referring to the ease and rapidity with which a transaction can take place. For the purposes of this paper, liquidity refers to bank funding liquidity or the ease with which banks can obtain funds to continue to support assets on their balance sheets.

**Mortgage Backed Security:** A security made up of cash flows from a collection of residential mortgages.

**OIS:** The Overnight Index Swap rate. This rate represents the fixed portion of a swap contract that exchanges interest rate payments on some notional principle value where the interest rates are determined

by the effective Federal Funds rate. The fixed portion of this swap represents the expected geometric average of the Federal Funds rate over a fixed time period (1-month or 3-month for the purposes of my analysis).

PDCF: Primary Dealer Credit Facility. The program functioned as a discount window analogue for investment banks through which primary dealers (financial institutions that have established trading relationships with the Federal Reserve) could access short-term funds while posting collateral of the same types allowed in discount window borrowing. The PDCF was announced on March 16<sup>th</sup>, 2008.

Primary Credit: The amount of money outstanding through the Federal Reserve's discount window facility at a given time.

Repurchase agreement (Repo): An agreement which effectively extends a collateralized loan to a borrower. A repo agreement is an agreement by a borrower to sell a pre-determined basket of collateral to a lender for a specified period of time with an accompanying agreement to repurchase these securities at a later date and generally at a higher price than the collateral was sold for the spread between the two transactions representing the interest payment on the loan. Repurchase agreements were used extensively by investment banks that were heavily involved in the securitization market for residential mortgages.

Swap Lines: A program announced on December 12<sup>th</sup>, 2007 by the Federal Reserve to make dollar funding accessible to banks outside of the Federal Reserve Board's jurisdiction. The swap lines program enabled the European Central Bank and the Swiss Bank (and later the Bank of England, Bank of Japan, and other international central banks) to access dollar funding by exchanging a fixed amount of Euros or Swiss Francs for dollars at the market exchange rate and entering an agreement to make an offsetting transaction (whereby the foreign central bank repurchases its currency using dollars) at the same exchange rate, plus interest, at a set future date.

TAF: Term auction facility. A program introduced by the Federal Reserve on December 12<sup>th</sup>, 2007 to relieve financial strains in money market and counteract the stigma associated with the Fed's conventional emergency lending facility, the discount window, by proactively injecting liquidity into the banking system through an auction format.

TSLF: Term Securities Lending Facility. A facility through which investment banks could place bids to swap a basket of approved collateral (with an appropriate haircut) for a basket of Treasury Securities for a term of 28 days.

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