On the Effectiveness of the Federal Reserve's New Liquidity Facilities

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Abstract

This paper examines the effectiveness of the new liquidity facilities that the Federal Reserve established in response to the recent financial crisis. I develop a no-arbitrage based affine term structure model with default risk and conduct a thorough factor analysis of the counterparty default risk among major financial institutions and the underlying mortgage default risk. The new facilities' effectiveness is examined, by first separately examining their effects in relieving financial institutions' liquidity concerns and reducing the counterparty risk premiums, and then quantifying their overall effects in reducing financial strains in the inter-bank money market.

Empirical results indicate that the Term Auction Facility (TAF) has a strong effect in reducing financial strains in the inter-bank money market, primarily through relieving financial institutions' liquidity concerns. Heightened uncertainty regarding the macroeconomy, financial markets, and mortgage default risk have significantly raised counterparty risk premiums among financial institutions, but have had little effect on their liquidity premiums. The Term Securities Lending Facility (TSLF) and the Primary Dealer Credit Facility (PDCF), however, are found to have had less discernible effects so far in relieving financial strains in the Libor market. This is consistent with market observations of a weaker interest from primary dealers in participating in the TSLF auctions than banks have shown in tapping the TAF.

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1. Introduction

Since early August 2007, financial markets in the U.S. and Europe have undergone a sustained period of financial distress, originating from the meltdown of the subprime mortgage market. During this period of turbulences, short-term financing costs have at times jumped precipitously. For instance, the 3-month unsecured Libor spread over the Overnight Inter-bank Swap (OIS) rate, a measure often used to gauge the tension in inter-bank money market, jumped from under 10 basis points in early August 2007 to almost 100 basis points within a month (Chart 1).

In response to the rapidly deteriorating financial conditions, central banks around the world resorted to the conventional monetary policy toolbox at first, including the Federal Reserve's efforts in cutting the discount rate and extending the terms of loans through discount window. As it became apparent that conventional tools were not effective enough in addressing unusual financial distress, the Federal Reserve introduced several new facilities including the Term Auction Facility (TAF) to provide liquidity to the market. Some other central banks, such as Bank of Canada, the European Central Bank, and the Swiss National Bank also took measures to increase term lending. Despite these efforts, however, considerable strains in the money market remained through the spring of 2008.

This situation naturally leads to a debate about the effectiveness of these new liquidity facilities. In particular, while several Federal Reserve officials including Mishkin (February 15, 2008) state that the Term Auction Facility (TAF), "may have had significant beneficial effects on financial markets," some other researchers are less confident. In a recent working paper, Taylor and William (2008) claim that they have not found evidence suggesting that the TAF has helped relieve the strains. This controversy calls for a careful examination of the effectiveness of these new liquidity facilities, which is the focus of the current paper.

Financial strains in the inter-bank money market can result from either heightened counterparty default risk among financial institutions, or increased liquidity demand, both leading to an increased unwillingness of financial firms to lend to each other and a rise in the posted borrowing costs. To fully evaluate the TAF and other liquidity facilities, we need to examine their effects on both dimensions. This turns out to be very challenging, as neither the counterparty risk nor liquidity demand is directly observable, or has readily available proxies. More importantly, conditions in subprime mortgage and overall financial markets have deteriorated substantially since the beginning of the financial stress, and the monetary policy and macroeconomic environment have also changed considerably. These factors make it very difficult to identify the effects of the new liquidity facilities from those of the deteriorating financial market and macroeconomic conditions.

To address these problems, I use real-time financial market evaluations of default risk for various financial institutions to measure counterparty risk and mortgage default risk. In particular, I conduct a thorough factor analysis to examine variation of systematic default risk among major commercial banks and investment banks, as well as the systematic default risk among firms heavily exposed to subprime mortgage risk. I then analyze the effectiveness of the Federal Reserve's new liquidity facilities, by first separately examining their effects in relieving financial institutions' liquidity concerns and in reducing the counterparty risk premiums, and then quantifying their overall effects in reducing financial strains in the inter-bank money market. The specifications of the regression models and choice of regressors are guided by a no-arbitrage based affine term structure model with default risk that is developed in the paper.

The empirical results suggest that the Term Auction Facility (TAF) has strong effects in relieving the liquidity concerns in the inter-bank money market, yet has little effect in lowering the counterparty risk premiums among major financial institutions. On the other hand, most of the variation in systematic counterparty risk premiums can be attributed to heightened uncertainty regarding the macroeconomy, financial markets, and underlying mortgage default risk, which appear to have had little effect on banks' demand for liquidity.

When I combine these effects and account for the possible correlations between counterparty risk premiums and banks' liquidity concerns, I find that the TAF has, on average, reduced the 1-month Libor-OIS spread by at least 31 basis points, and the 3-month Libor-OIS spread by at least 44 basis points. This provides evidence suggesting that the TAF has helped relieve financial stress in the inter-bank money market. The other two newly introduced liquidity facilities, the Term Securities Lending Facility (TSLF) and the Primary Dealer Credit Facility (PDCF), are found to have less discernible effect so far on Libor-OIS spreads, consistent with the market observations of a weaker interest from the primary dealers in participating in the TSLF auctions.

The broad contour of this analysis is consistent with recent research on credit-default risk and no-arbitrage based Credit Default Swap (CDS) pricing, as well as on the transmission mechanism of monetary policy, and has a direct bearing on asset pricing literature and monetary economics.

More recently, Taylor and Williams (2008) and McAndrews, Sarkar, and Wang (2008) address the same questions as this paper but arrive at different conclusions. There are three distinctive features of my study that can possibly explain this discrepancy. First, I examine the overall effects of the TAF and other facilities since they were established, whereas the other two papers take an event-study approach and focus on the TAF's effect on some specific days, either the bid submission days (Taylor and Williams), or the TAF announcement day and the following auction days (McAndrews et. al.). Both of these two papers assume that the TAF has no effect on the other trading days. Second, I conduct a thorough factor analysis to examine the *systematic* counterparty risk among major financial institutions, based on which the empirical regressions are conducted. I also control for the systematic mortgage default risk and various uncertainties regarding the macroeconomy and financial markets in examining the TAF and the TSLF effect, which are ignored by the other authors. Finally, I separate the new facilities' effects in lowering the counterparty risk premiums from those relieving liquidity concerns, similar to Bank of England (2007) and McAndrews, Sarkar, and Wang (2008), although my analysis is along a completely different approach and makes less restrictive assumptions. In contrast, Taylor and Williams (2008) dismiss the liquidity concerns and only focus on the counterparty risk.

The rest of the paper is organized as follows. Section 2 provides a brief chronology of financial market developments around the establishment of the TAF and other new liquidity facilities, and discusses the transmission mechanisms through which these new facilities may possibly work. Section 3 formulates a no-arbitrage based affine term structure model with default risk, providing a theoretical framework for the empirical analysis. Section 4 examines the effects of the Federal Reserve's new liquidity facilities, first separately on their effects in relieving the liquidity concerns and in reducing the counterparty risk, and then their overall effects in reducing the financial strains in the money market. It also examines the TAF auction-day effect. Section 5 concludes.

2. A Chronology of Financial Developments in 2007-2008

2.1. Financial Conditions Prior to the TAF

The ongoing financial crisis has deep roots in the deterioration of sub-prime mortgage market conditions, which began to emerge in late 2006 and early 2007. On February 7, 2007, New

Century Financial Corp. announced a restatement of its 2006 performance from a profit to a substantial loss, which was followed by a number of hedge funds failures and writedowns from investment banks, mainly suffering from the collapse of Mortgage Backed Securities (MBS) and other related financial derivatives. However, the crisis did not spread to money market until several months later. On August 9, 2007, the French investment bank BNP halted redemptions from three of its subsidiary mutual funds, and in response to this event, overnight interest rates shot up in European and U.S. money markets.

The deterioration of the inter-bank market conditions had greatly impaired the stability of short-term funding markets and posed severe challenges to central banks' ability to provide ample liquidity through regular monetary policy channels. For example, under normal circumstances, the Federal Reserve has two ways to inject liquidity into the market, through open market operations, and by lending at its discount window. However, as explained below, these had not adequately addressed the unusual financial market distress this time.

Open market operations are the most powerful and frequently used policy tool by the Federal Reserve to inject liquidity into market, at a rate close to the target rate set by the Federal Open Market Committee (FOMC). On the open market, the Federal Reserve trades with a selected set of "primary dealers," through direct purchases or sales of Treasury or government agency securities, or repurchase agreements against such securities. The liquidity is then redistributed by these dealers to other financial institutions in the inter-bank money market, and finally spreads to other sectors of the economy. However, during periods of marked financial turmoil like that since the summer of 2007, a heightened reluctance for banks to lend to each other in the inter-bank money market will interrupt this process and can lead to a credit crunch that may slow the overall economy.

The second tool used by the Federal Reserve to supply liquidity is the discount window. Sound depository institutions in need of extra liquidity can go to the Federal Reserve and obtain funding, through fully collateralized overnight loans, at a rate usually higher than the federal funds rate. From 2003 through the summer of 2007, the discount rate had been maintained at 100 basis points above the federal funds rate target.

In response to the soaring strains in the money market, the Federal Reserve narrowed the discount rate premium, from 100 basis points to 50 basis points on August 17, 2007, immediately after the initial jump in money-market interest rates, and further down to 25 basis points on

March 17, 2008. The terms of loans through discount window were also extended to up to thirty days in August 2007 and further extended to ninety days later, and such loans are renewable at the request of the borrowers. These measures were taken to encourage banks' borrowing through the discount window. However, their effects had been modest, due to the so-called "stigma" problem: during a financial crisis, the banks may be reluctant to borrow from the discount window, worrying that such actions would be interpreted by the market as a sign of their financial weakness, which would reduce their ability to borrow from the market.

2.2. The Creation of the TAF and Other Liquidity Facilities

As the strains in term funding markets persisted and became particularly elevated in early December, the Federal Reserve introduced a new lending facility, namely, the Term Auction Facility (TAF). With this new facility, the Federal Reserve auctions a pre-announced amount of credit, twice in each month, to eligible depository institutions that are in sound financial condition, for a term of one month (28 days or 35 days) instead of overnight. The TAF accepts the same kind of collateral as the discount window. The amount of the credit was initially set at $20 billion for each auction, and was then increased to $30 billion in January 2008 and $50 billion in March 2008.

In addition to the TAF, two new lending facilities were also created in March 2008 to serve as extra channels in providing liquidity to financial institutions in need. On March 11, 2008, the Federal Reserve announced the creation of Term Securities Lending Facility (TSLF), offering to lend to its primary dealers, including non-depository institutions, Treasury securities through weekly auctions with total amount up to $200 billion, for a term of 28 days. Specifically, in exchange for lending Treasuries, the TSLF accepts AAA/Aaa-rated private-label mortgage-backed securities (MBS) and asset-backed securities as collateral. The first auction was conducted on March 27, 2008, with an offering size of $75 billion. As the Federal Reserve states, the purpose of the TSLF is to "promote liquidity in the financing markets for Treasury and other collateral and thus foster the functioning of financial markets more generally."

Finally, on March 16, 2008, the Federal Reserve announced that it would establish a Primary Dealer Credit Facility (PDCF), which authorizes overnight loans to its primary dealers at the discount rate secured by eligible investment-grade securities. This facility essentially extends the discount window, which has been only opened to depository institutions, to non-depository financial institutions including investment banks. The facility, "will be in place for at least six months." Table 1 compares the main features of these three new liquidity facilities with those of the regular open market operations and the discount window.

2.3. Transmission Mechanism (Why Should The New Facilities Work?)

In the several weeks following the establishment of the TAF on December 12, 2007, credit conditions in the inter-bank market improved substantially. As Chart 1 shows, the 1-month Libor spread over the Overnight Inter-bank Swap (OIS) rate dropped sharply from the peak of 111 basis points in early December to below 30 basis points in late January. However, the spread bounced back in early March to about 60 basis points and continued to rise since, exceeding 80 basis points in mid-April. The early spring upswing has raised doubts about the effectiveness of the TAF and the other two new facilities.

During a financial turmoil, banks become increasingly reluctant to lend to each other for two reasons. First, counterparty risk or default risk increases as the uncertainty around the counterparty's financial conditions rises. Second, banks tend to build up precautionary liquidity as uncertainty about the market value of their own assets (e.g., structured credit products) mounts. The cost and availability of funding to keep these structured products on their balance sheet has also tightened. Furthermore, fund managers may also demand extra liquidity readily available to cover potential redemptions.[1] Heightened counterparty risk and extra liquidity demand lead to an increased unwillingness to lend and has likely contributed to the jumps in inter-bank interest rates.

By establishing lending facilities that are ready to provide funding to financial institutions in need, the Federal Reserve has sought to relieve the financial strains through several channels. The first and most direct channel is to serve as an additional funding source for banks in immediate need of liquidity, thereby lowering the short-term borrowing costs. Second, because the new facilities reduce pressure on banks to liquidate their assets, these facilities should lessen further upward pressures on their funding costs induced by deteriorations in money market conditions. This may contribute to a decline in the counterparty risk, *ceteris paribus*, and thereby lower risk

[1] More specifically, these are concerns over *funding liquidity*, i.e., risks when an institution is unable to raise cash to hold its balance-sheet position, rather than a *trading liquidity*, which often refers to difficulties to execute a transaction at the prevailing market price due to a temporary lack of appetite for the transaction by other traders on the market.

premiums. Third, with strengthened confidence the investors may ask for less compensation for a given unit of risk, i.e., the risk price may decline in the presence of the TAF. Thus the risk premium, which is the product of risk compensation per unit of risk and perceived amount of risk, should also decline. Finally, with this additional funding source readily available, there is less demand for banks to excessively hoard liquidity purely out of individual precautionary concerns.

The new liquidity facilities do not increase the total reserves in the system. The reason is simple: to keep the federal funds rate at the target level, after each TAF auction the Federal Reserve will conduct an opposite transaction on the open market, to maintain the total reserves unchanged (Chart 2). Based on this observation, Taylor and Williams (2008) suggest that the TAF should not work in reducing the financial strains, because the total amount of liquidity has not increased.

However, under the current disrupted market conditions, the effectiveness of the TAF and other liquidity facilities depends on whether they can resolve the misallocation of liquidity in the market, not necessarily how much net overall reserves the Federal Reserve is injecting into the market. Recall that the current credit crunch results from an increased unwillingness among the banks to lend to each other, due to both heightened counterparty risk and elevated liquidity demand. Therefore, it is the misallocation of liquidity, not the lack of total reserves, that is afflicting the market. By providing short-term funding to banks in immediate need of liquidity through these new facilities while absorbing the excess reserves from the others on the open market, the Federal Reserve serves as an intermediary between these financial institutions, with a goal of trying to achieve a more efficient allocation of liquidity without changing the total supply of reserves in the system.

In summary, there are reasons to believe that the TAF and the other new liquidity facilities could and should effectively alleviate financial strains in the inter-bank money market.

3. A No-arbitrage based Term Structure Model of LIBOR Rates with Default Risk

Let us describe the economy by fixing a filtered probability space $\{\Omega, \mathcal{F}, P\}$ and a family $\{\mathcal{F}_t : t \geq 0\}$ of σ-algebra. In particular, assume that an N-dimensional vector F_t can describe the state of the economy and follows an affine diffusion process under the physical measure P:

$$dF_t = -\kappa(\Theta - F_t)dt + \Sigma\sqrt{S_t}dW_t \tag{3.1}$$

where Θ is the long-run mean of F_t and κ controls the mean-reverting speed. Σ is a full-ranked matrix and S_t a diagonal matrix with the i-th diagonal elements defined as

$$[S_t]_{ii} = \alpha_{ii} + \beta'_{ii}F_t \tag{3.2}$$

for some $N \times N$ diagonal matrices α and β. W_t denotes a standard Wiener process.

I further define $F_t = [F'_{rt}, F'_{dt}]'$, where F_{rt} are state variables that determine the default-free bond yields. These may include latent factors such as level, slope, curvature as found in term structure literature, or interest rates of different maturities as in the "interest rate only" model in Duffie and Kan (1996), and macro factors as examined in macro-finance literature such as Ang and Piazzesi (2003), Wu (2006), and Rudebusch and Wu (2007), etc. F_{dt} includes state variables that are related to default risk. Therefore, the default-free instantaneous interest rate can be written as

$$r_t = \delta_0 + \delta'_1 F_{rt}. \tag{3.3}$$

Furthermore, I assume the following recursive structure for κ and Σ to keep the default-free bond yields strictly a function of the default-free term structure factors F_{rt}

$$\kappa = \begin{bmatrix} \kappa_r & 0 \\ \kappa_{rd} & \kappa_d \end{bmatrix}, \Sigma = \begin{bmatrix} \Sigma_r & 0 \\ \Sigma_{rd} & \Sigma_d \end{bmatrix} \tag{3.4}$$

The absence of arbitrage opportunity and an assumption of a complete market ensure the existence of a unique pricing kernel M_t under the physical measure, which is assumed to follow

$$\frac{dM_t}{M_t} = -r_t - \lambda'_t dW_t \tag{3.5}$$

where $\lambda_t = \lambda_0 + \lambda'_1 F_t$ is an N- dimensional vector of market price of risk. λ_1 preserves a recursive structure

$$\lambda_1 = \begin{bmatrix} \lambda_{1r} & 0 \\ \lambda_{1rd} & \lambda_{1dd} \end{bmatrix} \tag{3.6}$$

that is, the risk price for covering default-free interest rate risks only depends on the default-free term structure factors F_{rt}.

With this affine risk-price specification, the factor dynamics remain affine under risk-neutral measure $\mathbb{Q}$

$$dF_t = -\kappa^{\mathbb{Q}}(\Theta^{\mathbb{Q}} - F_t)dt + \Sigma\sqrt{S_t}dW_t^{\mathbb{Q}} \tag{3.7}$$

with $\kappa^{\mathbb{Q}} = \kappa + \lambda_1$ and $\kappa^{\mathbb{Q}}\Theta^{\mathbb{Q}} = -\lambda_0$. Then one can show that the price of a τ-period default-free bond $b_{\tau t}$ is

$$b_{\tau t} = E^{\mathbb{Q}}[\exp(-\int_t^{t+\tau} r_s ds)|\mathcal{F}_t] \tag{3.8}$$

and can be solved as

$$b_{\tau t} = \exp(A_\tau - B'_\tau F_{rt}) \tag{3.9}$$

The factor loadings A_τ and B_τ are solutions to the following ordinary differential equations (ODEs):

$$\begin{aligned} \frac{dA_\tau}{d\tau} &= -\delta_0 - \Theta_r^{\mathbb{Q}\prime}\kappa_r^{\mathbb{Q}\prime}B_\tau + \frac{1}{2}B'_\tau\Sigma_r\alpha_r\Sigma'_rB_\tau \\ \frac{dB_\tau}{d\tau} &= \delta_1 - \kappa_r^{\mathbb{Q}\prime}B_\tau - \frac{1}{2}B'_\tau\Sigma_r\beta_r\Sigma'_rB_\tau \end{aligned} \tag{3.10}$$

subject to boundary conditions $A_0 = 0$ and $B_0 = 0$. $\Theta_r^{\mathbb{Q}}$ and $\kappa_r^{\mathbb{Q}}$ denote the long-run mean and transition matrix associated with the default-free term structure factors F_{rt}. α_r and β_r are the submatrices of α and β corresponding to F_{rt}. The yield to maturity of the default-free bond is also affine:

$$r_{\tau t} = -\frac{A_\tau}{\tau} + \frac{B'_\tau}{\tau}F_{rt} \tag{3.11}$$

Now let us switch to the pricing of the defaultable bonds. Here I follow Duffie and Singleton (1999) and define the fair value of a τ-period defaultable zero-coupon bond as

$$b^D_{\tau t} = E^{\mathbb{Q}}\{\exp[-\int_t^{t+\tau}(r_s + g_s)ds)|\mathcal{F}_t], \tag{3.12}$$

where g_t denotes the instantaneous default spread, which is the product of a hazard rate h_t (the instantaneous default probability) and a fractional loss l_t, and follows an affine process

$$g_t = \delta_0^D + \delta_1^{D\prime}F_t. \tag{3.13}$$

Note that the instantaneous default spread g_t is a function of F_t, i.e., both the default-free term structure factors F_{rt} and other state variables that are related to default risk F_{dt}. Thus the price of the τ-period defaultable zero-coupon bond is also exponential affine

$$b^D_{\tau t} = \exp(A^D_\tau - B^{D\prime}_\tau F_t) \tag{3.14}$$

where the factor loadings A^D_τ and B^D_τ are solutions to the following ODEs

$$\frac{dA^D_\tau}{d\tau} = -(\delta_0 + \delta_0^D) - \Theta^{\mathbb{Q}\prime}\kappa^{\mathbb{Q}\prime}B_\tau + \frac{1}{2}B'_\tau\Sigma\alpha\Sigma'B_\tau \tag{3.15}$$

$$\frac{dB^D_\tau}{d\tau} = (\delta_1 + \delta_1^D) - \kappa^{\mathbb{Q}\prime}B_\tau - \frac{1}{2}B'_\tau\Sigma\beta\Sigma'B_\tau \tag{3.16}$$

subject to boundary conditions $A_0^D = 0$ and $B_0^D = 0$. Likewise, the yield to maturity is also affine

$$r_{\tau t}^D = -\frac{A_\tau^D}{\tau} + \frac{B_\tau^{D\prime}}{\tau} F_t \tag{3.17}$$

Hence, the default spread on this τ-period defaultable zero-coupon bond is

$$\begin{aligned} r_{\tau t}^D - r_{\tau t} &= -\frac{A_\tau^D - A_\tau^D}{\tau} + \frac{B_\tau^{D\prime}}{\tau} F_t - \frac{B_\tau^\prime}{\tau} F_{rt} \\ &= -\frac{A_\tau^D - A_\tau}{\tau} + \frac{B_{r\tau}^{D\prime} - B_\tau^\prime}{\tau} F_{rt} + \frac{B_{d\tau}^{D\prime}}{\tau} F_{dt} \end{aligned} \tag{3.18}$$

where $B_{r\tau}^D$ and $B_{r\tau}^D$ are the defaultable bond's factor loadings on F_{rt} and F_{dt}, respectively.

A Credit Default Swap (CDS) is a contract that provides insurance against the risk of a default by particular company. The buyer of the CDS makes periodic payments to the seller until the end of the life of the CDS. Should the company fail to meet its obligations, the buyer is paid the face value in exchange for the underlying securities or simply a cash equivalent for the loss. Therefore, the CDS rate serves as an insurance premium, and a higher CDS rate simple indicates that the market is demanding higher premiums to cover the associated default risk.

If we assume that there are no liquidity concerns in the CDS market and that the guarantee will always be honored, then the no-arbitrage condition will ensure that a τ-period CDS rate is identical to the default spread derived from default and default-free term structure (equation 3.18)

$$r_{\tau t}^{CDS} \equiv r_{\tau t}^D - r_{\tau t} = -\frac{A_\tau^D - A_\tau}{\tau} + \frac{B_{r\tau}^{D\prime} - B_\tau^\prime}{\tau} F_{rt} + \frac{B_{d\tau}^{D\prime}}{\tau} F_{dt} \tag{3.19}$$

i.e., an affine function of the underlying state variables.

4. Empirical Analysis

The empirical analysis consists of the following steps. First, I will assess the TAF's effect in lowering money market liquidity premiums, by controlling for variation in systematic counterparty risk premiums. I then examine the effects of the TAF and other facilities in reducing counterparty risk premiums. Finally I account for the possible correlations between liquidity and counterparty risk premiums and evaluate the overall effect of the TAF and the TSLF and PDCF. The sample runs from January 1, 2007 to April 24, 2008, a total of 344 trading days.

The specification of the regression equations is guided by the theoretical model in Section 3. In particular, equations (3.18) and (3.19) suggest that, in the absence of liquidity concerns and other market distortions, there is a one-for-one mapping between the Libor default spread and the CDS rate of the same maturity, and that both are linear functions of the underlying default and default-free term structure factors. Therefore, I adopt the following regression model

$$L_t = \alpha_1 + \beta_1 * r_t^{CDS} + \beta_{1,TAF} * TAF + u_t \tag{4.1}$$

where L_t denotes the 1-month or 3-month Libor-OIS spread. r_t^{CDS} represents the systematic default risk among financial institutions. TAF is a dummy for the Term Auction Facility, and u_t is the regression residuals, both capturing the liquidity concerns and other market distortions. The coefficient of the CDS rate is not restricted to one, because the maturity of the available CDS rate is much longer than 1 or 3 months (the most popular CDS contracts are set for a five year maturity). Next, I will explore the determination of the systematic counterparty risk premiums by regressing r_t^{CDS} on a set of state variables X_t,

$$r_t^{CDS} = \alpha_2 + \beta_2 X_t + \beta_{2,TAF} * TAF + \xi_t \tag{4.2}$$

as equation (3.19) suggests. Finally, a comprehensive investigation of the determination of the Libor spreads will be conducted by running the following regression

$$L_t = \alpha + \beta_X X_t + \beta_{TAF} * TAF + \varepsilon_t \tag{4.3}$$

as I substitute equation (3.19) into (4.1).

There are several important data measurement issues that need to be addressed in estimating these equations. First, throughout the empirical analysis, I use the 1-month and 3-month Libor spreads over the Overnight Inter-bank Swap (OIS) rate to measure the funding strains in the inter-bank money market. The OIS rate closely matches the average of the expected overnight interest rate over the contract maturity and is a good measure of the prevailing default-free term loan rate. Thus the Libor-OIS spread measures the premium that the market demands to cover the default risk on Libor loans, as well as the compensation for risk associated with the lender's liquidity demand.[2] The 1-month or 3-month Treasury bill rates, although being the natural choice to measure the default-free interest rates during normal time, are less desirable here

[2] The Libor rate is quoted everyday at 11:00 a.m. GMT, i.e., 6:00 a.m. EST, whereas the OIS rate is quoted at 4:30 p.m. EST, which is a whole U.S. trading day later than when the Libor is determined. To account for this discrepancy, I also defined alternative Libor-OIS spreads using previous day's OIS rate, and obtained very similar estimates of the TAF and the TSLF effects (I thank John Driscoll for making this suggestion).

because during periods of financial turbulence, they are affected by shifts in liquidity preference associated with "flight to quality" effects.

Secondly, in defining the TAF dummy variable, I treat the establishment of the TAF as signaling the beginning a new "regime" in the money market. Accordingly, the TAF dummy is set to one for all trading days since December 12, 2007, and zero for all days prior. This differs from the other studies, such as Taylor and Williams (2008) and McAndrews, Sarkar, and Wang (2008), which, in order to evaluate the TAF's effect on some specific days (bidding days as in Taylor and Williams and announcement and auction days in McAndrews et.al), define a dummy taking the value of one only on the TAF bidding or auction days and zero otherwise, including both the pre-TAF trading days and the non-bidding days after the TAF was established. In contrast, since this study aims to quantify the overall effect of the TAF, I naturally chose to set the dummy value to zero only for the pre-TAF days and one thereafter.

Thirdly, I also define a dummy variable for the Term Securities Lending Facility ($TSLF$), in the same way that the TAF dummy is defined. On the other hand, I do not define a separate dummy for the Primary Dealer Credit Facility (PDCF), because its targeted customers are the same as the TSLF (both are for primary dealers), and the facility was introduced around the same time that the TSLF was established. These two reasons make it very difficult to distinguish between the effects of these two facilities, which are not the focus of this study.

Finally, when quantifying the default risk, instead of using the CDS rates for *individual* banks and investment banks as in Taylor and Williams (2008), I use a measure of *systematic* default risk premiums. In particular, I extract the first principal component of the individual CDS rates from a group of the largest U.S. commercial banks (Chart 3), and use it to proxy the systematic default risk premiums for these banks. Similarly, a systematic default risk factor is also constructed for major investment banks and is included in the regressions (Chart 4). These factors turn out to capture the co-movement of the CDS rates for individual banks and investment banks very well. For instance, the single factor extracted from the seven largest U.S. commercial banks captures 97 percent of total variation in their individual CDS rates, and the single factor extracted from the top five U.S. investment banks can explain almost 98 percent of their individual CDS rates, indicating that these extracted factors are very good measures of the systematic counterparty risk over time.

4.1. The TAF's Effect in Reducing Liquidity Premiums

For this moment let us assume that the counterparty risk premiums are uncorrelated with the liquidity premiums, so that we can measure the TAF's effect in reducing banks' liquidity concerns by controlling for systematic counterparty risk. This assumption is also made by Taylor and Williams (2008) and McAndrews et.al (2008). Regression results are reported in Table 2, with t-statistics reported in the parentheses.

Not surprisingly, the systematic counterparty risk factors have substantial and statistically significant effect on the Libor spreads, indicating that much of the unusual widening in the Libor spreads reflects heightened counterparty default risk. On the other hand, the TAF is found to have substantially reduced financial strains in the money market through lowering the liquidity concerns. For instance, columns (1) and (2) suggest that the TAF has reduced the 1-month Libor-OIS spread by 26 to 31 basis points on average, and columns (3) and (4) indicate an even larger effect on the 3-month Libor-OIS spread. Moreover, all the TAF coefficients are statistically significant at 5 percent level.

Such results contradict Taylor and Williams (2008), in which a similar regression study is conducted and the TAF coefficient estimates are generally positive and insignificant. The difference in our results mainly stems from using different definitions of the TAF dummy, reflecting different interpretations of how the TAF works. Taylor and Williams (2008) assume that the only days on which the TAF may work are the bid submission days, and that the TAF has no effect in reducing the Libor-OIS spreads on the non-bidding days. However, note that the terms loans under the TAF have a maturity of 28 or 35 days, so one would expect that such loans would be able to relieve the financial strains for the duration of the loans as the Federal Reserve intended, i.e., four or five weeks, rather than only on one day. Moreover, the arrangement of holding bi-weekly auctions ensures that the TAF loan periods always overlap, so that a certain amount of term loans would always be kept in the market to reduce liquidity strains. Therefore, it seems more appropriate to define the TAF dummy as equalling one for all trading days after the TAF was established as described above, rather than only on the auction bidding days.

Further experiments confirm this conjecture. When I replace the systematic default risk factor in column (1) by the individual CDS rates for Bank of America (or Citi Group) as Taylor and Williams (2008) chose, while keeping the TAF dummy definition unchanged, the estimated TAF coefficient is still significantly negative, at -0.26 (or -0.22). In other words, if we run

Taylor and Williams' regressions with a re-defined TAF dummy, the estimation results would still indicate a statistically significant TAF effect in reducing Libor-OIS spreads.

4.2. The TAF's Effect in Reducing the Counterparty Risk Premiums

Next I evaluate the TAF's effect in reducing systematic counterparty risk premiums. As equations (3.18) and (3.19) suggest, the systematic default risk premiums may be determined by a broad range of macro and financial variables, including aggregate risks posed by the macroeconomy and financial markets. To this end, I examine three measures of aggregate uncertainty in the regressions: the Merrill Lynch MOVE index to measure the implied volatility in the longer-term U.S. Treasury market, the VIX measure of implied volatility from options on the S&P 500 index to measure uncertainty in the stock market, and the implied volatility from 3-month Eurodollar options to measure the uncertainty about the near-term path of monetary policy.

To control for the underlying subprime mortgage risk, I also construct a "mortgage default risk" factor, defined as the first principal component of the individual CDS rates for a group of the largest subprime mortgage lenders, mortgage bond insurers, and residential construction companies. These firms represent sectors that are most heavily exposed to subprime mortgage market turmoil, but have no access to the TAF or the TSLF. Therefore their CDS rates are an ideal measure of the underlying mortgage default risk and should help identifying the TAF and the TSLF effects. Chart 5 displays the constructed "mortgage default risk" factor and the individual CDS rate for a selected group of these mortgage-related companies.

Tables 3 and 4 report the regression results for modeling the systematic default risk factors for commercial and investment banks, respectively. I first conduct a preliminary analysis of the importance of various macroeconomic and financial-market volatilities and mortgage risk by regressing the Libor spreads on each of these variables (columns 1 to 4). All the coefficients on the three volatility variables are positive and significant at 1 percent level, and the adjusted R^2 is around 85 percent or even higher, indicating a strong correlation between the heightened uncertainties in the macroeconomy and financial markets and the increased counterparty risk premiums among major financial institutions. In addition, the constructed "mortgage default risk" factor also has a statistically significant effect on counterparty risk premiums in the Libor market, as one would anticipate (column 4). When all four volatility or risk measures are included in a multivariate regression, as shown in column 5, coefficients of the MOVE index and the mortgage default risk factor remain positive and significant at 1 percent level, but coefficients of the VIX and Euro dollar volatility become less significant, suggesting that the uncertainty on the longer-term Treasury market and the mortgage default risk are more closely correlated with financial strains in the Libor market.

On the other hand, the point estimates of the TAF and the $TSLF$ coefficients are positive in most cases, suggesting that the Fed's new lending facilities have *not* been able to reduce the counterparty default risk premiums. This could result from the fact that the constructed "mortgage default risk" factor is still not a perfect measure and may only capture part of the heightened mortgage default risk. For instance, it may suffer a truncation problem, in the sense that the observed CDS rates are all those from the survived subprime mortgage-exposed firms, and do not incorporate the highly risky ones which already went bankruptcy or whose CDS were stopped trading. Therefore, in running the regressions, a substantial part of the soaring counterparty risk in the money market is left unexplained by the "mortgage default risk" factor and is passed onto the coefficient estimates of the two dummy variables, thus yielding a spurious positive sign. This can also be seen from the observation that, when the constructed "mortgage default risk" factor is not included in the regressions (columns 1 to 3 in both tables), the TAF and $TSLF$ coefficients are large and statistically significant; but when the constructed "mortgage default risk" factor is included so that part of the counterparty default risk is accounted for by the "mortgage default risk" factor (columns 4 to 6), the TAF and the $TSLF$ coefficient estimates become smaller, not statistically significant, and in some cases negative. On the other hand, one may argue that these regression results still indicate that the TAF and the TSLF do not have a very strong effect in lowering the counterparty risk premiums, at least not strong enough to offset the effects from the elevated mortgage default risk which are not captured by the constructed "mortgage default risk" factor.

4.3. The Overall Effect of the TAF, the TSLF and the PDCF

Finally I proceed to quantify the overall effect of the TAF, the TSLF and the PDCF in relieving the financial stress in the Libor market, both through relieving banks' funding liquidity concerns and lowering their counterparty risk premiums. Again, as guided by equation (4.1), I regress the 1-month and 3-month Libor-OIS spreads on a set of variables measuring the overall macroeconomic and financial market volatilities, as well as the constructed "mortgage default risk" factor.

However, I do not control for counterparty risk premiums in running the regressions, because we would like to take into account the TAF and the TSLF's effects on such risk premiums. For the same reason, I choose not to include a measure of the volatility of the Libor-OIS spread in the regressions, as the TAF and the TSLF may also work through lowering Libor spread volatility, thereby lowering risk premiums and the level of Libor spread.

Again, I first run a set of univariate regressions, examining the individual correlations between the Libor spreads and various volatility and risk measures. Two different specifications are adopted in the estimation, in which the TAF (and the $TSLF$) dummy enters either as an independent regressor, or through the interactions with one of the volatility or risk measures. These two specifications aim to describe two different channels for the new liquidity facilities to affect money market conditions: either by directly lowering the Libor spreads by a fixed amount, or by proportionally lowering the impact of heightened mortgage risk as well as macro and financial volatilities on Libor spreads.

Tables 5 and 6 report the univariate regression results for the 1-month and 3-month spreads, respectively. These regressions use a pre-TSLF sample running from January 1, 2007 to March 10, 2008, the day prior to the announcement of the TSLF. In both specifications, coefficient estimates of all four volatility and risk measures are positive and statistically significant at 1 percent level, as one would expect. Moreover, the TAF dummy coefficient estimates are all negative and significant at 1 percent level in most cases, indicating significant TAF effects in narrowing the Libor-OIS spreads.

Next I run a set of multivariate regressions, including both the TAF dummy and the $TSLF$ dummy, based on the whole sample period. As shown in Tables 7 and 8 for 1-month and 3-month spreads, respectively, the volatility of the longer-term Treasury market (MOVE) has the strongest and most statistically significant effect contributing to financial strains in the Libor market. Other volatility measures and the mortgage default risk measure have much smaller effects and most of them are insignificant. In particular, the VIX coefficient estimate is slightly negative, possibly capturing a "flight to quality" effect reflecting investors' tendency to move assets from stock market into money market when the volatility of the stock market increases. The coefficient of the "mortgage default risk factor" also becomes negative, possibly due to the fact that the constructed factor is not a perfect measure of the overall mortgage default risk and may underestimate increases in overall mortgage default risk (e.g., truncation problem discussed above). For this reason, its effect is also likely underestimated.

On the other hand, the TAF is found to have substantial and statistically significant effects in narrowing Libor-OIS spreads. In particular, after controlling for various macroeconomic and financial volatility and risk measures, the TAF has on average reduced the 1-month Libor-OIS spread by 31 basis points, and the 3-month Libor-OIS spread by 44 basis points (columns 1 and 3 in Tables 7 and 8). Moreover, when the TAF dummy enters the equation through interactions with the volatility and risk measures (columns 2 and 4 in Tables 7 and 8), most of the coefficient estimates of the interactions are negative and significant at 1 percent level, confirming a strong TAF effect in lowering the Libor-OIS spreads. The high adjusted R^2's (65-79 percent in 1-month Libor spreads and 73-89 percent in 3-month Libor spreads) even without including the CDS rates for major financial institutions or autoregressive terms in the regressions, indicate that these variables account for much of the variation in Libor spreads.[3] Moreover, it is interesting to note that, of the two model specifications, the one in which the TAF and the $TSLF$ enter through interactions with other volatility or risk measures does a noticeably better job in explaining the variation in the Libor spreads than the one in which they enter as independent regressors.

However, there is less evidence of a discernible effect of the TSLF and the PDCF in lowering the Libor spreads. Columns (3) in both tables report a positive and statistically significant $TSLF$ coefficient estimates, and most of the coefficients estimates of the TSLF interactions are also positive. The only negative and significant $TSLF$ coefficient estimate occurs in its interactions with the MOVE index. This negative evaluation of the TSLF and the PDCF could simply result from a lack of enough observations since these two new facilities were introduced only in March 2008, around the same time the money market turbulence became elevated again. On the other hand, this result may also suggest that the TSLF and the PDCF have been a less effective policy tool than the TAF has been so far. Such a conclusion is consistent with the market observations that the primary dealers showed a weaker interest in using the TSLF than banks have shown in tapping the TAF. Indeed, in two out of the five TSLF auctions conducted through early May 2008 (on April 10, 2008 and April 24, 2008, respectively), the submitted bidding amount at the TSLF auction was indeed substantially lower than the amount offered by the Fed.

[3] For robustness check, I also ran regressions including the lagged Libor spreads in the equation and obtained the same conclusions. The only difference is that the implied effects of the TAF and the TSLF in the autoregressive models are even larger than those reported here.

Finally, as both Taylor and Williams (2008) and McAndrews, Sarkar, and Wang (2008) have adopted an event-study approach and analyzed the TAF effect on the TAF auction days, I assess the auction-day effects of the TAF as well. To this end, I define another dummy variable for the TAF bid submission days, in the same way as Taylor and Williams (2008), and run the regressions based on the pre-TSLF sub-sample. As shown in Table 9, the bid submission-day effect is quite limited: on such days, on average the extra TAF effect only reduces the 1-month Libor-OIS spread by less than 3 basis points, and the 3-month Libor-OIS spread by about 3 or 6 basis points, and such effects are statistically insignificant. This result is consistent with other authors' findings, and is not surprising at all. Indeed, in principle one should not expect a strong TAF bidding-day effect, because the TAF auctions including the auction dates, amounts, and other auction terms are all announced well in advance, so the actual auctions can hardly be any "surprise" to a rational market. Indeed, by its design, the TAF facility was not intended to affect money market conditions on *only* TAF auction days.

5. Concluding Remarks

This paper examines the effectiveness of the new liquidity facilities that the Federal Reserve established in response to the recent financial crisis. I develop a no-arbitrage based affine term structure model with default risk and conduct a thorough factor analysis of the counterparty default risk among major financial institutions and the underlying mortgage default risk. The new facilities' effectiveness is examined, by first separately examining their effects in relieving financial institutions' liquidity concerns and reducing the counterparty risk premiums, and then quantifying their overall effects in reducing financial strains in the inter-bank money market.

Empirical results indicate that the Term Auction Facility (TAF) has a strong effect in reducing financial strains in the inter-bank money market, primarily through relieving financial institutions' liquidity concerns. Heightened uncertainty regarding the macroeconomy, financial markets, and mortgage default risk have significantly raised counterparty risk premiums among financial institutions, but have had little effect on their liquidity premiums. The Term Securities Lending Facility (TSLF) and the Primary Dealer Credit Facility (PDCF), however, are found to have had less discernible effects so far in relieving financial strains in the Libor market. This is consistent with market observations of a weaker interest from primary dealers in participating in the TSLF auctions than banks have shown in tapping the TAF.

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Table 1: Federal Reserve's Toolbox

	Open Market Operations	Discount Window	TAF	TSLF	PDCF
Agents	primary dealers	depository institutions	depository institutions	primary dealers	primary dealers
Rate charged	Fed. funds rate	discount rate	through auction	through auction	discount rate
Term of loans	overnight	overnight, extended to 90 days	28 or 35 days	28 days	overnight, renewable to up to 120 days
Renewability	—	renewable	—	—	renewable
Eligible collateral	Treasury or gov't agency securities	Treasury, gov't & investment-grade private issues and bank loans	same as discount window	AAA-rated MBS and asset-backed securities	same as discount window, but no loans or synthetic securities
Frequency	daily	daily	bi-weekly	weekly	daily

Table 2: TAF's Effect on Libor-OIS Spread

	1-month Libor-OIS spread		3-month Libor-OIS spread	
	(1)	(2)	(3)	(4)
Bank default risk	0.1099**		0.1525**	
	(5.1532)		(9.2299)	
Investment bank default risk		0.1482**		0.1869**
		(4.5947)		(4.9270)
TAF dummy	-0.3068*	-0.2646*	-0.4001**	-0.2576*
	(-2.3995)	(-2.3316)	(-4.1989)	(-2.4189)
Adj. R^2	0.3249	0.3579	0.5175	0.4866

Note: t-statistics are displayed in parentheses (based on Newey-West standard errors). *(**) denotes statistical significance at the 95% (99%) confidence level.

Table 3: Counterparty Default Risk Among Major Commercial Banks

	Systematic Bank Default Risk Factor					
	(1)	(2)	(3)	(4)	(5)	(6)
MOVE	0.0396**				0.0196**	0.0173**
	(11.4721)				(4.3675)	(3.9827)
VIX		0.1711**			-0.0039	0.0320
		(9.8595)			(-0.2033)	(1.6338)
Euro $ volatility			0.0892**		-0.0346*	-0.0375*
			(8.3740)		(-2.2125)	(-2.4921)
Mortgage default risk				0.3029**	0.3091**	0.2503**
				(14.9570)	(10.1367)	(5.8438)
TAF dummy	1.8130**	3.0250**	1.9304**	0.3411		0.6936*
	(5.3571)	(11.4127)	(4.3101)	(0.9147)		(1.9730)
TSLF dummy	0.9995**	0.9898**	0.8680*	0.5261		0.6760
	(2.7865)	(2.6692)	(2.0231)	(0.9559)		(1.3270)
Adj. R^2	0.8785	0.8667	0.8445	0.8992	0.8999	0.9006

Note: t-statistics are displayed in parentheses (based on Newey-West standard errors). *(**) denotes statistical significance at the 95% (99%) confidence level.

Table 4: Counterparty Default Risk Among Major Investment Banks

	Systematic Investment Bank Default Risk Factor					
	(1)	(2)	(3)	(4)	(5)	(6)
MOVE	0.0334**				0.0098**	0.0112**
	(21.1859)				(2.9477)	(3.6878)
VIX		0.1441**			0.0298*	0.0455**
		(22.2492)			(2.4652)	(4.4356)
Euro $ volatility			0.0856**		0.0289*	0.0218*
			(15.1269)		(2.0149)	(2.2122)
Mortgage default risk				0.2189**	0.0965**	0.0575**
				(25.9548)	(5.8137)	(2.5811)
TAF dummy	0.3632*	1.3796**	0.1900	-0.3941		0.1218
	(2.0539)	(6.7718)	(0.7790)	(-1.6664)		(0.7149)
TSLF dummy	2.5489**	2.4828**	2.3756**	2.2559*		2.3351**
	(3.1161)	(2.8348)	(3.0161)	(2.3522)		(2.8070)
Adj. R^2	0.8798	0.8672	0.8628	0.8475	0.8316	0.8886

Note: t-statistics are displayed in parentheses (based on Newey-West standard errors). *(**) denotes statistical significance at the 95% (99%) confidence level.

Table 5: Overall Effects of the New Liquidity Facilities: 1-month Libor-OIS Spread, Univariate Regressions

	1-month Libor-OIS spread							
	MOVE		VIX		Euro $ volatility		Mortgage default risk	
MOVE	0.0094** (12.7633)	0.0098** (13.6815)						
MOVE * TAF		-0.0033** (-7.1292)						
VIX			0.0310** (8.3348)	0.0322** (8.5030)				
VIX*TAF				-0.0039 (-1.5971)				
Euro $ volatility					0.0142** (5.0615)	0.0242** (9.4342)		
Euro*TAF						-0.0145** (-5.9344)		
Mortgage default risk							0.0362** (4.4077)	0.0495** (5.8717)
Mortgage*TAF								-0.0339** (-4.2508)
TAF dummy	-0.4521** (-6.4950)		-0.0707 (-1.0925)		-0.2002* (-1.7377)		-0.3470* (-2.2395)	
Adj. R^2	0.6371	0.6580	0.3850	0.3923	0.2778	0.4467	0.2324	0.3364

Note: t-statistics are displayed in parentheses (based on Newey-West standard errors). All columns are based on observations prior to March 11, 2008. *(**) denotes statistical significance at the 95% (99%) confidence level.

Table 6: Overall Effects of the New Liquidity Facilities: 3-month Libor-OIS Spread, Univariate Regressions

	3-month Libor-OIS spread							
	MOVE		VIX		Euro $ volatility		Mortgage default risk	
MOVE	0.0110** (22.2242)	0.0115** (27.1751)						
MOVE * TAF		-0.0033 (-10.0502)**						
VIX			0.0404** (12.5857)	0.0415** (12.7173)				
VIX*TAF				-0.0021 (-0.9583)				
Euro $ volatility					0.0196** (7.0631)	0.0313** (15.7105)		
Euro*TAF						-0.0168** (-8.1545)		
Mortgage default risk							0.0557** (8.6863)	0.0706** (12.0977)
Mortgage*TAF								-0.0432** (-7.2048)
TAF dummy	-0.4424** (-8.5758)		-0.0241 (-0.4275)		-0.2227* (-1.9742)		-0.4825** (-3.6095)	
Adj. R^2	0.7559	0.7776	0.5598	0.5625	0.4560	0.6322	0.4609	0.5746

Note: t-statistics are displayed in parentheses (based on Newey-West standard errors). All columns are based on observations prior to March 11, 2008. *(**) denotes statistical significance at the 95% (99%) confidence level.

Table 7: Overall Effects of the New Liquidity Facilities: 1-month Libor-OIS Spread, Multivariate Regressions

	(1)	(2)	(3)	(4)
MOVE	0.0139**	0.0116**	0.0128**	0.0114**
	(8.3594)	(6.4791)	(7.3506)	(6.2916)
MOVE*TAF		-0.0025		-0.0024
		(-1.2963)		(-1.2259)
MOVE*TSLF				-0.0238**
				(-5.5115)
VIX	-0.0022	-0.0206**	-0.0043	-0.0214**
	(-0.3389)	(-3.1193)	(-0.6388)	(-3.2287)
VIX*TAF		0.0449**		0.0454**
		(4.2066)		(4.2486)
VIX*TSLF				0.0128
				(0.5475)
Euro $ volatility	-0.0045	0.0153**	-0.0041	0.0161**
	(-1.2020)	(3.6640)	(-1.0666)	(3.8236)
Euro vol.*TAF		-0.0247**		-0.0252**
		(-5.1251)		(-5.2221)
Euro vol.*TSLF				0.0073
				(0.8638)
Mortgage default risk	-0.0239**	-0.0203*	-0.0173*	-0.0193*
	(-2.9239)	(-2.2273)	(-1.9397)	(-2.0958)
Mort*TAF		-0.0235*		-0.0248*
		(-1.7546)		(-1.8396)
Mort*TSLF				0.1700**
				(9.6514)
TAF dummy	-0.3076**		-0.3203**	
	(-3.0458)		(-2.9715)	
TSLF dummy			0.2843**	
			(2.9230)	
Adj. R^2	0.6917	0.7800	0.6422	0.7855

Note: t-statistics are displayed in parentheses (based on Newey-West standard errors). Columns (1) and (2) are based on observations prior to March 11, 2008. *(**) denotes statistical significance at the 95% (99%) confidence level.

Table 8: Overall Effects of the New Liquidity Facilities:
3-month Libor-OIS Spread, Multivariate Regressions

	(1)	(2)	(3)	(4)
MOVE	0.0123**	0.0086**	0.0114**	0.0084**
	(11.2067)	(9.1299)	(9.8032)	(8.8235)
MOVE*TAF		-0.0015		-0.0014
		(-1.1923)		(-1.1071)
MOVE*TSLF				-0.0175**
				(-5.1131)
VIX	-0.0017	-0.0264**	-0.0029	-0.0272**
	(-0.2977)	(-6.1969)	(-0.5075)	(-6.3769)
VIX*TAF		0.0530**		0.0535**
		(6.5777)		(6.6731)
VIX*TSLF				0.0062
				(0.3619)
Euro $ volatility	-0.0028	0.0249**	-0.0031	0.0255**
	(-0.7065)	(9.7520)	(-0.7853)	(9.8939)
Euro vol.*TAF		-0.0343**		-0.0347**
		(-9.3460)		(-9.4554)
Euro vol.*TSLF				0.0034
				(0.4796)
Mortgage default risk	-0.0004	0.0072	0.0051	0.0080
	(-0.0533)	(1.0383)	(0.7004)	(1.1412)
Mort*TAF		-0.0380**		-0.0391**
		(-3.3668)		(-3.4545)
Mort*TSLF				0.1335**
				(8.8300)
TAF dummy	-0.4406**		-0.4424**	
	(-5.0548)		(-4.9435)	
TSLF dummy			0.1808*	
			(2.0027)	
Adj. R^2	0.7474	0.8827	0.7250	0.8849

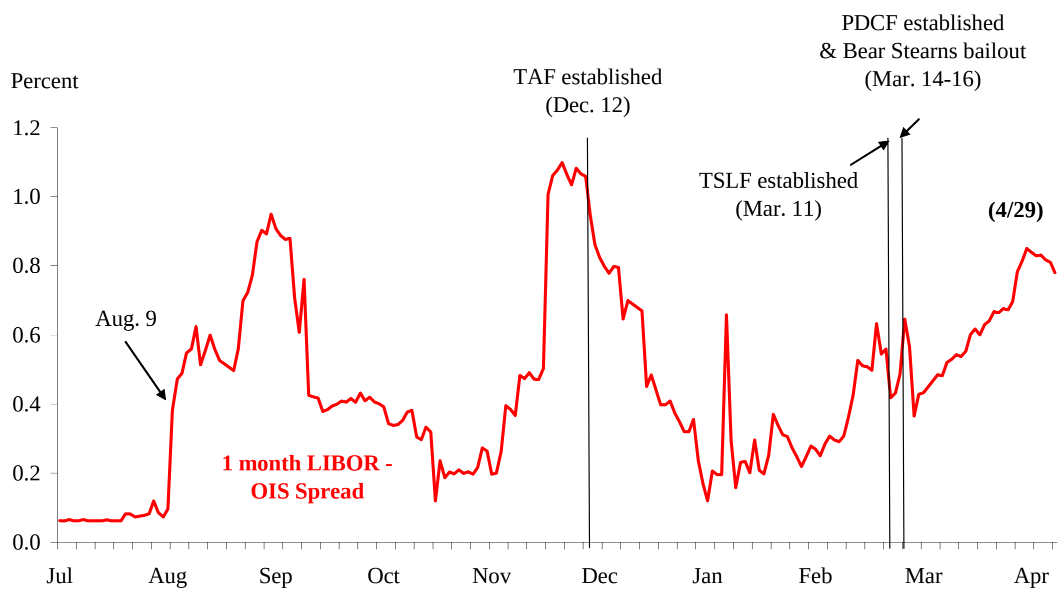
Note: t-statistics are displayed in parentheses (based on Newey-West standard errors). Columns (1) and (2) are based on observations prior to March 11, 2008. *(**) denotes statistical significance at the 95% (99%) confidence level.

Table 9: TAF Bidding-day Effect

	1-month Libor-OIS spread				3-month Libor-OIS spread			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MOVE	0.0136**	0.0136**	0.0113**	0.0113**	0.0126**	0.0127**	0.0092**	0.0092**
	(10.8271)	(10.8354)	(7.3765)	(7.3747)	(15.2081)	(15.3852)	(10.9366)	(10.9519)
MOVE*TAF			-0.0021	-0.0020			-0.0016	-0.0015**
			(-1.0803)	(-1.0701)			(-1.2951)	(-5.8306)
VIX	-0.0060	-0.0061	-0.0233**	-0.0233**	0.0007	0.0006	-0.0239**	-0.0239**
	(-1.2015)	(-1.2144)	(-4.3756)	(-4.3753)	(0.1433)	(0.1126)	(-5.8351)	(10.2588)
VIX*TAF			0.0243*	0.0243*			0.0367**	0.0363
			(2.4232)	(2.4120)			(4.5772)	(-1.2069)
Euro $ volatility	-0.0097**	-0.0097**	0.0115**	0.0115**	-0.0054*	-0.0054*	0.0249**	0.0249**
	(-3.2918)	(-3.2874)	(3.2042)	(3.2019)	(-1.8239)	(-1.8375)	(10.2692)	(4.5323)
Euro*TAF			-0.0265**	-0.0265**			-0.0389**	-0.0389**
			(-6.0043)	(-6.0030)			(-12.5748)	(-12.5898)
TAF dummy	-0.4337**	-0.4311**			-0.4121**	-0.4062**		
	(-6.5528)	(-6.5536)			(-7.0943)	(-6.9668)		
TAF bidding day dummy		-0.0266		-0.0023		-0.0620		-0.0329
		(-0.3875)		(-0.0411)		(-0.9080)		(-0.7526)
Adj. R^2	0.6814	0.6794	0.7489	0.7465	0.7593	0.7578	0.8686	0.8661

Note: t-statistics are displayed in parentheses (based on Newey-West standard errors). All columns are based on observations prior to March 11, 2008. *(**) denotes statistical significance at the 95% (99%) confidence level.

Chart 1
Soring Strains in the Inter-bank Money Market



Note: Spreads based on prime (nonfinancial and financial) commercial paper rate until 1996; financial paper thereafter.
Source: Federal Reserve Board, Moody's, Bloomberg and author's calculations.

Chart 2
Total Reserves Have Been Quite Stable

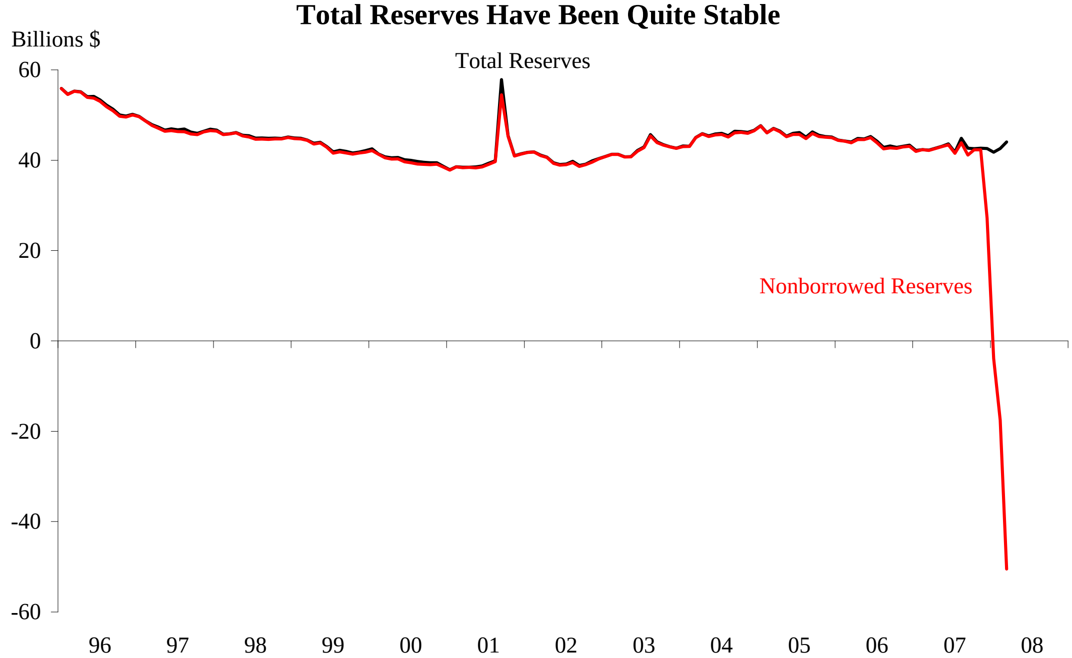


Chart 3
Systematic Default Risk of Major Commercial Banks

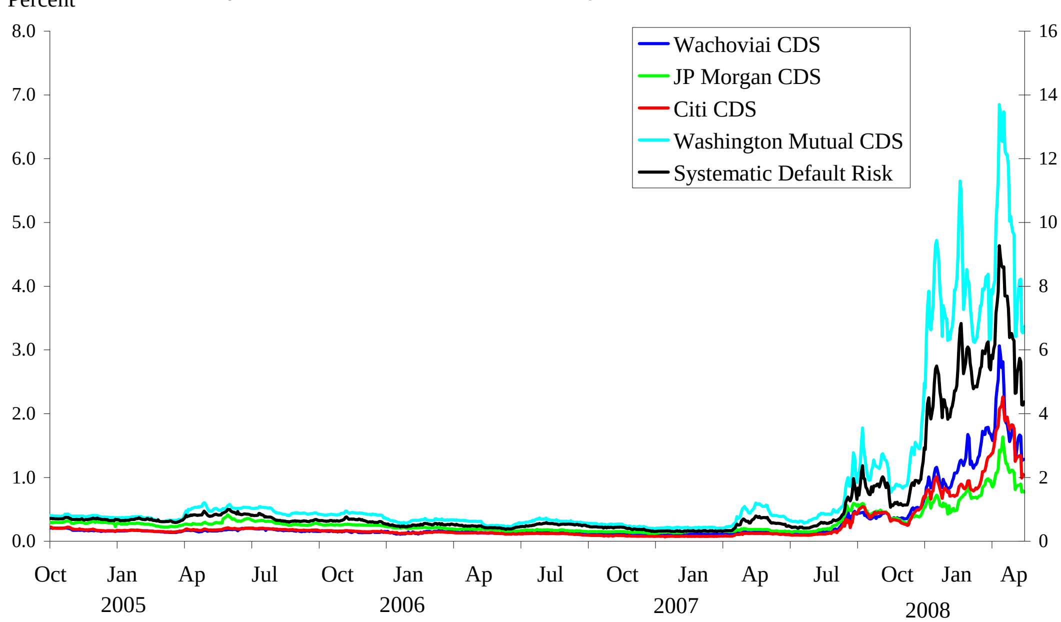


Chart 4
Systematic Default Risk of Major Investment Banks

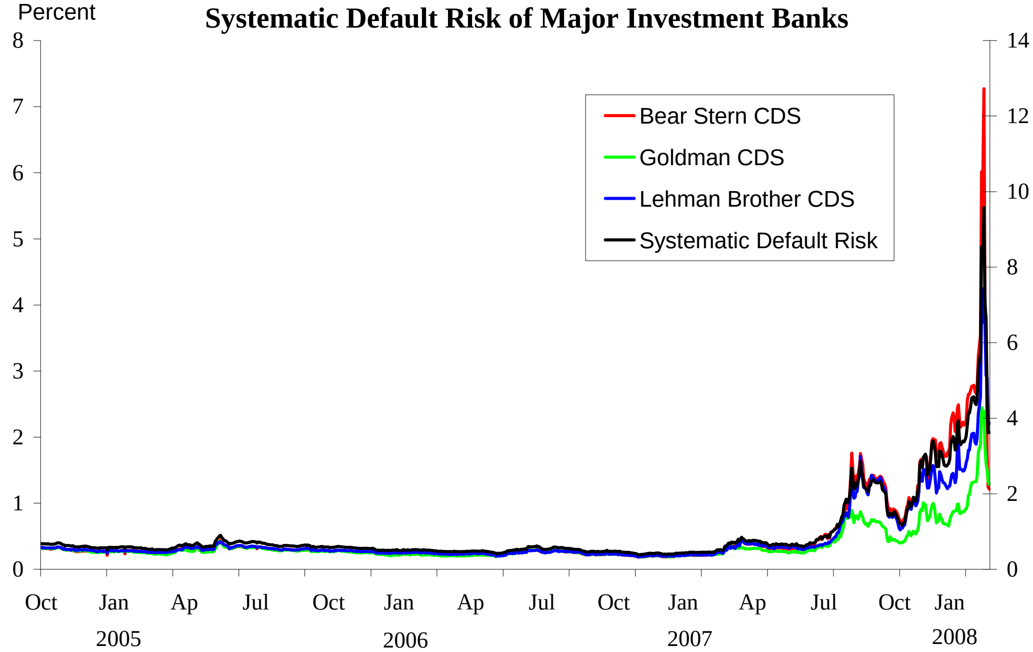


Chart 5
Systematic Mortgage Default Risk