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Too TAF towards the risk

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Abstract

During the last financial crisis the Federal Reserve launched several extraordinary actions, including the creation of a number of new facilities for auctioning short-term credit, with the general aim of sustaining the financial sector and of ensuring adequate access to liquidity to financial institutions. One of these programs has been the Term Auction Facility (TAF).

The goal of this paper is two-fold. First, we want to study banks' liquidity and liability features depending on whether banks received credit from the TAF program. Second, we want to measure the impact of program facilities on banks liquidity risk.

In order to achieve these goals we fit a treatment effects model. In the first step the probability of obtaining TAF program facilities has been instrumented by a set of variables measured before the beginning of the TAF program. In the second step, once controlled for potential selection bias and endogeneity, the impact of TAF facilities on banks liquidity risk, posterior to the end of the program, has been measured.

The results suggest that, on average, banks that obtained program facilities show higher short term net liabilities, higher volume of short term liabilities and higher short term liabilities over total liabilities. These banks exhibit as well a smaller ratio of short term liabilities over total assets and risk-free assets over short term liabilities.

Moreover, it has been found that banks that obtained at some point TAF facilities exhibit smaller ex post liquidity risk as well as that ex ante liquidity risk positively affects the probability of receiving program facilities. Several robustness checks confirm the main results.

Our findings support the view point that the Federal Reserve correctly identified the program target banks and it also achieved the goal of decreasing liquidity risk.

Keywords TAF, Liquidity Risk, Financial Crisis

JEL Classification G21, G28, G32

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1 Introduction

The bursting of the housing bubble in 2007 led to the most severe financial crisis since the Great Depression. As banks were forced to write down billions of dollars in bad loans, the inter-bank market for short-term funding collapsed. On the one hand, this led to a deterioration of the reciprocal trust between banks so that the inter-bank market froze; on the other hand, banks with liquidity needs were reluctant to use the Fed's traditional channel of the discount window facility. Banks aversion was due to the fact that this strategy could have been interpreted by the market as a signal of being in financial trouble, therefore intensifying the pressure on the financial institution.

In this context, the Federal Reserve has been directly involved in promoting several extraordinary actions, including the creation of a number of new facilities for auctioning short-term credit, with the general aim of sustaining the financial sector and of ensuring that financial institutions have adequate access to liquidity. One of these program has been the Term Auction Facility (TAF). The specific aim of this program was to inject liquidity into the market, effectively substituting the inter-bank markets. The TAF program was set up by the Fed in December 2007, and lasted till April 2011, when the last loans were repaid.

The goal of this paper is two-fold. First, we want to study banks' liquidity and liability features depending on whether they received credit from the TAF program. Second, we want to measure the impact of program facilities on banks liquidity risk. Studying the impact we concentrate on the long-run effect of the TAF program, assessing how the banks that benefited from TAF funds got out of the crisis.

Giving an answer to this set of questions is relevant in order to assess whether the program was well designed (did the facilities go to banks that really need them?), and to check how the facilities affected the liquidity risk once the program was over (did the fact of obtaining the facilities increase or decrease banks *funding liquidity* risk?).

In order to achieve the goals of this study, we contrast the liquidity levels in 2010.Q3 with the levels in 2007.Q3, distinguishing as well between banks that received the facilities and the others. Moreover, for the banks that received the facilities we document their funding liquidity risk behaviour from twenty periods before to ten periods after receiving the facility. Finally, for assessing the impact of the program on the funding liquidity risk we adopt a treatment effect model. In this way it is possible to control for potential selection bias that could arise if banks that received the facilities are different, in terms of liquidity risk, with respect to the rest of the banks, already before receiving the funds.

At a glance, we find that banks that benefited from the facilities exhibit higher level of liquidity risk proxies. The various measures indicate that banks with a more severe maturity mismatch were most exposed to the freezing of the interbank market and were unable to roll over their short-term liabilities during the crisis. Furthermore, we find that the banks that benefited from the facilities drastically reduce their funding liquidity risk positions just after receiving for the first time the financial sustain. Previous results are also confirmed by the econometric analysis. Specifically, the results highlight that ex ante higher level of liquidity risk makes the participation to the program more likely, while TAF facilities decrease ex post liquidity risk levels. These results are robust to changes of the time period for defining the ex ante period, to different estimation methodologies and to alternative proxies for liquidity risk.

Our findings suggests that Federal Reserve correctly identified the program target banks and it also achieved the goal of decreasing liquidity risk. In terms of policy implications, we identify banks that are more prone to liquidity needs, and we show that the TAF program helped to alleviate the exposure to short-term financing. One possible conclusion is that future bank regulation should not only concentrate on capitalisation, but also on measures of maturity and/or liquidity mismatches.

While previous studies analyse how the TAF program affected the liquidity risk premium, this is –to our knowledge– the first contribution focusing on volume effects of the TAF program by using micro banking data. Our approach shows several advantages with respect to that employed in previous contributions. Specifically, the micro banking perspective allows us to avoid time series issues that may affect the results, as shown in previous studies. Moreover, by employing quantities instead of prices makes less likely that hidden mechanisms could affect the behaviour of the dynamics we are interested in. Finally, by studying the TAF effects on liquidity risk once the program was ended, we adopt a long run perspective, so that we do not have to deal with the issue of distinguishing between short and long run effects.

The rest of the paper is organized as follows: Section 2 contains the literature review; in Section 3 we discuss the TAF program and other programs in detail; the econometric model, the data set and the estimation methodology is presented in Section 4; in Sections 5 and 6 we show and discuss the results; finally, Section 7 concludes.

2 Literature Review

The effectiveness of the TAF program can be analysed from different perspectives. As the goal of the TAF program was to inject liquidity into the inter-bank market, previous contributions have focused on aggregate spreads measuring liquidity risk.

Taylor and William (2008a) approximate the liquidity risk premium by the spread between the London Interbank Offered Rate (LIBOR) and the overnight indexed swap (OIS). The level of the spread is regressed on a set of explanatory variables and dummy variables capturing the TAF bid submission rates. They find that the TAF dummies have no statistically significant impact on the spread.

McAndrews, Sarkar and Wang (2008) replace the spread level by its first difference in the specification employed by Taylor and William (2008a). The motivation for this choice is that liquidity premium changes are not temporary and they can persist once the TAF auction is over. The main finding is that the TAF program decreases the liquidity risk premium.

However, as pointed out by Taylor and William (2008b), these results are not robust to the period and to the specific TAF auction selected.

Wu (2008) improves previous specifications in several ways. On the one hand, a new set of explanatory variables is added in order to take exchange rate, stock and bond volatilities and mortgage default risk factor into account. On the other hand, the dummy variables capturing TAF effect have been redefined, based on the assumptions that the TAF program has a permanent effect and that the level of LIBOR-OIS spread is not persistent. It has been found that TAF program decreases both the 1-month and 3-months LIBOR-OIS spreads. Taylor and William (2008b) show that Wu's results are not robust because they depend on the sample period chosen. Another weakness of Wu's findings refers to the hypothesis about the permanent effect of the TAF program and the fact that the LIBOR-OIS spread is not persistent. Taylor and William show that neither of these assumptions hold.

Cui and Maharaj (2008) distinguish between short run and long run TAF effect. They find that LIBOR-OIS spread decreases when the TAF is announced, but TAF effect is not maintained over time. Moreover, they also find that TAF only affects 3-month spreads.

Sarkan and Shrader (2010) study the impact of TAF changes on 3 month-LIBOR over OIS spread changes by augmenting the specification employed by Taylor and William (2008a). They find that changes in the TAF amount have a negative impact on the changes in LIBOR-OIS spread. Moreover, they find that spread changes depend on the magnitude of the facility amount provided.

Christensen, Lopez and Rudebusch (2009) employ an alternative approach to estimate the effects of the TAF program. Specifically, they estimate a six-factor arbitrage-free model based on Nelson and Stiegel (1987) yield curve. They find that the TAF program lowers the 3-month LIBOR over T-bill spread by 80 basis points. Therefore, TAF program has a significant effect on decreasing liquidity premium. However, as pointed out by Thornton (2010), the LIBOR factor employed in previous contribution is based on the spread between the LIBOR and AA-rated financial corporate bonds. These spreads are highly correlated with risk spreads, therefore the results by Christensen et al. are not robust to the inclusion of the risk premium on financial bonds. Specifically, it is shown that the impact of TAF program on decreasing the LIBOR/T-bill is small or not relevant once the risk premium is included in the specification. According to this stand of the literature the effect of TAF program on liquidity risk premium is not clear: results depend on the period taken into account, on the variables included in the specification and on how the TAF program variable is modelled. The main results are summarized in the table below.

Table 1: TAF effect on liquidity risk premium

	Features	**TAF effect**
Taylor and William	spread at level	no effect
McAndrews et. al.	change in spread	negative
Wu	persistent TAF effect	negative
In et. al.	SR and LR effect	(SR only) negative
Christensen et. al.	factor analysis	negative
Thornton	factor analysis	no effect
Sarkan and Shrader	4 periods and TAF amounts	negative

Our contribution shows several differences with respect to previous studies. To our knowledge, this is the first contribution that focuses on micro banking data, instead of aggregate data. It follows that we do not incur in potential time series issues that affect previous studies. Moreover, this choice allows us to perform a more precise analysis of the impact of the TAF program on liquidity risk.

Furthermore, we focus on banks *funding liquidity* instead of *market liquidity*[1]. Specifically, we concentrate on the effect of TAF program on quantities instead of on prices (interest rate spreads). The reason is that prices are also impacted by other factors (e.g. see Michaud and Upper, 2008). Furthermore, during the financial crisis interest rates rose due to increased uncertainty and higher dispersion of credit quality. Finally, as stressed by Drehmann and

[1]This distinction has been clarified by Brunnermeier and Pederson (2008).

Nikolaou (2009) "But most importantly, the spread between interest rates in the interbank market and a risk free rate is purely a price measure and it does not reveal anything about market access, which maybe severely impaired during crisis, nor the volume of net-liquidity demand [...]."

Furthermore, our study assesses the impact of the TAF program once it was already over. This is not the case for previous contributions that are based on a period when the program was still working. It follows that we focus only on potential long run effects of the TAF program, "neutralizing" TAF program accountable effects affecting banks balance-sheets. Finally, our results are robust to the period taken into account, to the methodologies employed, to the sample features, and to the variable employed for measuring liquidity risk.

This study has features in common also with the literature that studies the impact of the last financial crises on bank and firms behaviour during the last financial crisis. Ivashina and Scharfstein (2010) analyse the behaviour of new loans and new lending for real investment. They find that banks with a better access to deposit financing cut their lending less. Finally, they also show the link between credit vulnerability, based on co-syndication with Lehman Brothers, and banks lending activity.
This contribution shares also some analogies with the study of Campello et. al. (2009) who study the corporate spending plans during the 2008 financial crises depending on credit constraints. and with the contribution of Campello et. al. (2010) who assess instead how firms managed liquidity during the financial crisis. They show that credit lines absorbed the impact of the financial crisis on corporate spending.

Finally, this contribution shares important features with a study of Puddu and Waelchli (2011) where the impact of TAF program on the composition of banks balance sheets is analysed. They find that banks that benefited from the program facilities decrease portfolio risk more than the other banks. In particular, banks that received the facilities increased the share of moderately risky assets while they decrease other type of assets (not risky, risky and extremely risky). Several robustness checks confirm the main results.

With respect to this stand of the literature our contribution is different because we employ an alternative benchmark to identify banks type, we focus on different periods and we address different issues. The common element is that we focus on events related with the last financial crisis.

3 Fed Facilities during the last financial Crisis

During the last financial crisis the Federal Reserve launched several extraordinary actions, including the creation of a number of new facilities for auctioning short-term credit, with the general aim of sustaining the financial sector and of ensuring adequate access to liquidity by financial institutions. In this section, we analyse in detail the TAF program as well as other programs launched by Fed during this period in order to underline their common points and their main differences.

3.1 Term Auction Facility program: how it works

According to the definition given by the Federal Reserve (Fed) “the TAF is a credit facility that allows a depository institution to place a bid for an advance from its local Federal Reserve Bank at an interest rate that is determined as the result of an auction”[2]. The aim of the TAF was to compensate for the collapse of the short-term funding market, by ensuring liquidity provisions when the inter-bank credit markets were under stress.

All banks that were in sound financial conditions[3] at the moment of the auction and during the term of TAF loans were eligible for the TAF. The facilities provided in the TAF program had maturity terms between 28 and 84 days and they had to be fully collateralized.

[2] http://www.federalreserve.gov/monetarypolicy/taffaq.htm

[3] This definition is opaque in the sense that there are not details about it. The soundness of a particular bank has to be certified by its local Reserve Bank. It refers to bank solvency, liquidity, and profitability.

Banks were allowed to have at the same time more than one loan, so that facilities with different maturities could overlap. The information about banks receiving funds was private.

For each auction the Fed fixed the total amount to supply, the maximum amount a bank was allowed to obtain, and the minimum bid interest rate (r_{Fed}). For each auction, eligible banks had the possibility to make two rate-amount offers. Specifically, the bid was characterized by the amount asked by the bank and a repayment interest rate. Bids were ordered according to the repayment interest rate bidden ($r_{Bank\,i}$). The Fed then began to accept the bids starting from that associated with the highest interest rate. It would continue to do so until the offered amount was reached, or all the bids were accepted. In the former case, the interest rate that had to be paid by all successful bidders was determined by the stop-out rate, i.e. by the interest rate of the last accepted bid. If the supply exceeded the demand, the equilibrium interest rate would simply be equal to the minimum bid rate. The equilibrium interest rate r^* is therefore

$$r^* = \begin{cases} r_{Fed} & \text{if } Supply > Demand \\ \widehat{r}_{Bank\,i} & \text{if } Supply \leq Demand \end{cases} \tag{1}$$

where $\widehat{r}_{Banki}$ is the lowest interest rate that was accepted by the Fed.

Although the TAF program was based on an auction system, its main goal was to inject liquidity in the inter bank credit market, by providing financial support to banks in liquidity distress. A normal way of proceeding, with banks asking for a loan at a normal discount window rate to the Fed, would have generated a signalling issue. The “stigma effect” during the last financial crisis has been discussed and measured by Armantier et. al. (2011) by using TAF program banks bids. They find that in the third quarter of 2008 banks preferred to pay on average at least 34 basis points more to borrow from the TAF program than from the discount window.

Assuming that the Fed has no interest in making profits by the implementation of these sort of programs (and actually this was the case), designing a system of financial sustain, based on auctions, has several important advantages in decreasing the potential stigma effect: the interest rate is determined through a market mechanism instead of being imposed by the authorities, the banks approach the Fed collectively instead of individually, and the information concerning the auction is private.

Figure 1: TAF facilities, market events, policy measures and liquidity risk

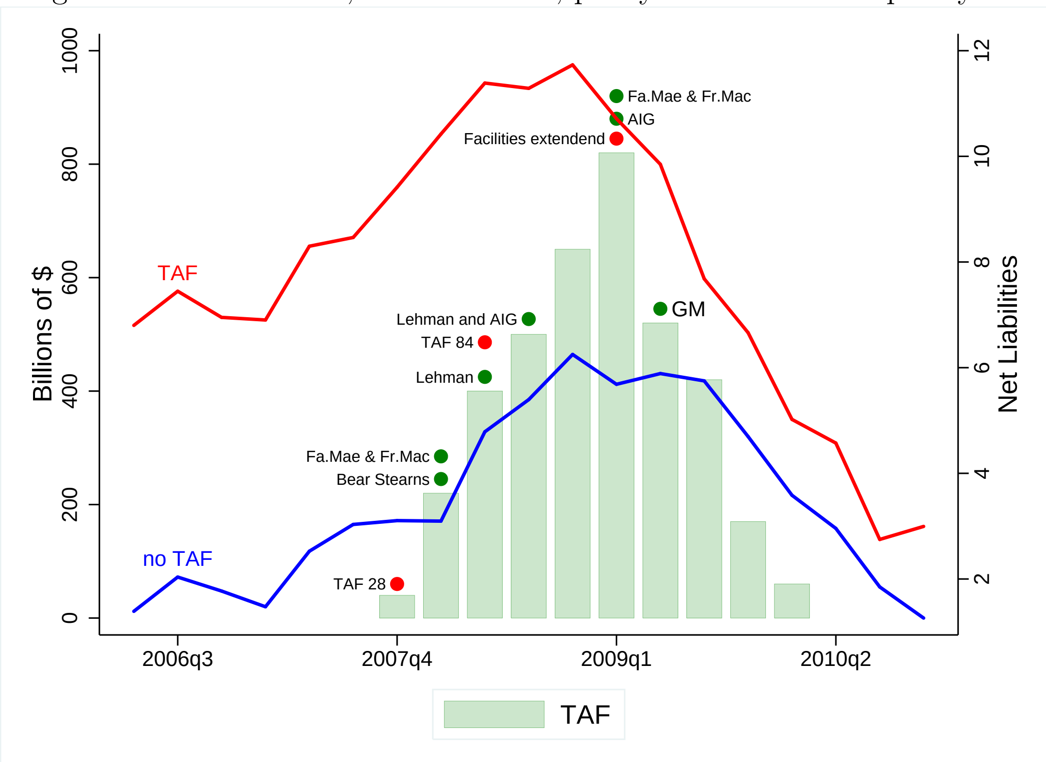


Figure 1 depicts the evolution over time of the amount of new facilities provided in each quarter. Moreover, several market events (green dots) and policy measures related to the TAF program (red dots) are reported. The program was announced on December 12, 2007. Specifically, the initial facilities had a maturity of 28 days. The amount provided was increased in the first quarter 2008, after Fannie Mae and Freddie Mac requirements were eased to allow for increases in lending and Bear Stearns received emergency loans from the

Fed. Only in 2008.Q2, after Lehman Brothers reported a loss of $2.8b, new facilities with longer maturities were established. The amount of new facilities kept rising after Lehman Brothers' bankruptcy and the downgrade of AIG debt. The maximum amount was supplied during 2009.Q1, when Fannie Mae and Freddie Mac reckoned a need of $51b to continue operations and AIG announced large losses. From 2009.Q2 on, new facilities decreased and lasted until March 8, 2010, when the last auction took place.

3.2 Other facilities

In March 2008 two additional programs have been launched by the Fed. The first one was the Term Securities Lending Facility (TSLF). It was a weekly loan facility, with the aim of promoting the functioning of financial markets, by offering "Treasury general collateral (GC) to the Federal Reserve Bank of New York's primary dealers in exchange for other program-eligible collateral"[4]. Its maturity term was of 28 days. The main difference between the TSLF and the TAF lies in the fact that the former offered Treasury GC to the New York Fed's primary dealers in exchange for other program-eligible collateral, while the latter offered term funding to depository institutions based on a auction system.

The second program opened in March 2008 was the Primary Dealer Credit Facility (PDCF). As the previous program its goal was to promote the functioning of financial markets by providing funding to the primary dealer through overnight loan facilities in exchange for any tri-party-eligible collateral. The difference of this program with respect to the TAF program refers to the maturity term of the loan (one day versus 28 or 84 days) and to the type of mechanism employed for allocating the facilities (exchange versus auction).

Three other programs, less related to the TAF program but nevertheless important, have been initiated by the Fed between October and November 2008. The Commercial Paper Funding Facility (CPFF) had the goal "of enhancing the liquidity of the commercial paper

[4]http://www.newyorkfed.org/markets/tslf_faq.html

market by increasing the availability of term commercial paper funding to issuers and by providing greater assurance to both issuers and investors that firms will be able to roll over their maturing commercial paper”[5].

The Money Market Investor Funding Facility (MMIFF) was a complement program of the CPFF. It “provided senior secured funding to a series of special purpose vehicles established by the private sector (SPVs) to finance the purchase of certain money market instruments from eligible investors”[6]. The main idea behind this program was to accommodate credit needs of businesses and households by improving the access to term financing from money market investors to banks and other financial intermediaries.

Finally, the Term Asset-Backed Securities Loan Facility (TALF) has been designed “to increase credit availability and support economic activity by facilitating renewed issuance of consumer and business asset-backed securities at more normal interest rate spreads. Under the TALF, the New York Fed will provide non-recourse funding to any eligible borrower owning eligible collateral”[7].

4 Empirical Evaluation

In this section we report a detailed analysis of our data set. Moreover, we summarize the main results at the glance, we present econometric model employed for answering the main questions addressed in this study and we discuss the associated potential econometric issues.

4.1 The data set

The dataset employed in this paper has been obtained by merging various datasets. The data concerning bank's balance sheet is a combination of the Report of Condition and Income

[5] http://www.newyorkfed.org/markets/cpff_faq.html
[6] http://www.newyorkfed.org/markets/mmiff_faq.html
[7] http://www.newyorkfed.org/markets/talf_faq.html

(generally referred to as Call Report) and the Uniform Bank Performance Report (UBPR). US banks are required by the Federal Financial Institutions Examination Council (FFIEC) to hand in these reports. The specific reporting requirements depend on the size of the bank and whether it has foreign offices. We accessed the Call Report data through the website of the Federal Reserve of Chicago and the UBPR data through the website of the FFIEC. The period taken into account goes from 2001.Q1 to 2010.Q4. The data on the TAF auctions are from the Federal Reserve Board. The sample covers the period from 2007.Q4 to 2010.Q1. The datasets have been merged and transformed so that we work with a cross-bank data set based on quarterly observations that include 8017 banks. Among them, 273 banks obtained TAF program facilities at least once. These banks represent approximately 3.4% of the total number of the banks in the sample.

By using TAF program as a disentangling event we can identify two periods. The before TAF program period has been approximated by measuring the values of the variables at 2007.Q3. In the robustness check we use two alternative proxies by considering the average values from 2006.Q3 to 2007.Q3 (short average) and the average values from 2001.Q1 to 2007.Q3 (long average). We employ the latest available data (i.e. 2010.Q3 at the time of writing) as proxy for the after TAF program period. In this way, we neutralize potential accountancy effects of the TAF program on the variables taken into account for approximating liquidity risk.[8]

4.2 Description of the variables

Since we are interested in the long-run TAF program effect, we distinguish between banks that received facilities through the TAF program at least once, and all the others. In our subsequent analysis, TAF always refers to the dummy variable that takes value 1 if a bank

[8]The descriptive statistics in Tables 4 and 5 are based on 2007.Q3 values as the before period. The baseline results are also based on this date.

received TAF facilities at least once, and 0 otherwise. There exist several arguments supporting the choice of not taking into account the number of times a bank benefited from the program or the amount of facilities received by each bank. First, we are interested on the effect of the TAF program on liquidity risk and not on "learning by bidding" effect that could be eventually captured by the the number of times a bank benefited from the program. Second, the correlation between our proxy for liquidity risk and the total amount of facilities per bank assets volume is .0632 and statistically not significant different from zero (p-value .3008)[9] so that its contribution in explaining the liquidity risk variation would be marginal.

Due to the fact that the TAF program goal was to decrease funding liquidity risk, we focus on variables that can proxy banks liquidity needs. As primary measure of funding liquidity risk we use a bank's exposure to short-term financing needs. Specifically, our benchmark results are based on net short term liabilities to total assets ($NET\ LIAB$). It is defined as short term liabilities less short term assets over total assets, and it is bounded between -100 and 100. Larger values of net liabilities correspond to higher level of liquidity risk. This choice is consistent with the definition provided by the Basel Committee of Banking Supervision. According to their definition liquidity is "the ability to fund increases in assets and meet obligations as they come due".

In the robustness checks we employ different measures of liquidity risk. Specifically, we focus on the log of risk-free assets to short term liabilities ratio ($PF\ RISK\ 0\ LIAB$), the log of short term assets over short term liabilities ($ST\ ASS\ LIAB$). The smaller the ratios the higher the liquidity risk. Moreover, we also focus on the short term liabilities over total liabilities ($ST\ LIAB\ TLIAB$), the log of short term liabilities over liquidity ($ST\ LIAB\ LIQ$) and the short term liabilities over total assets ($ST\ LIAB\ TASS$). Higher values reported by these indicators imply the higher the level of the liquidity risk. The first two alternative

[9]This result is robust to the measure of liquidity risk. The respective numbers are (p-values in parentheses) .0956 (.1178) for short-term liabilities over total liabilities, .0463 (.4518) for short-term liabilities over liquid assets, and $-.1207$ (.0493) for zero risk weight assets over short-term liabilities.

measures are "counter indicators" of the liquidity risk because they are proxy of the amount of "liquid" assets available for liquidity needs. The other proxies are instead direct indicator of liquidity risk, because they show how important short term liabilities are with respect to the total liabilities, and how the short term liabilities are relatively large with respect to liquidity or total assets.

The variables employed as controls refer to liquidity capacity, to banks portfolio assets composition, to banks different type of loans and finally to banks current and expected future loan losses, capital capacity and profitability.

As a proxy for liquidity capacity we employed two alternative measures. $LIQUIDITY$ is defined as the sum of total trading assets, total available-for-sale securities and total held-to-maturity securities over total assets, while $CASH$ is determined by cash and balances due from depository institutions over total assets.

Focusing on the banks portfolio assets composition we take into account the ratio of risk-weighted assets to total assets ($PF\ RISK$)[10]. This measure can be interpreted as a proxy of the portfolio risk: the higher this ratio, the higher the fraction of assets that are considered risky by the regulatory authorities. Moreover, we also take explicitly into account as control variables the fraction of each different category of assets consistently with Basel I accords.

We also include as explanatory variables banks loans measures. We considered total loans over total assets ($TLOANS$) as well as the ratio of different loan types over total loans. Specifically, we focus on commercial and industrial, real estate, individual and agricultural loans ($CI\ LOANS$, $REST\ LOANS$, $INDIV\ LOANS$ and $AGRI\ LOANS$, respectively).

Finally, we also consider as controls some features of the banks such as the $BUFFER$ that is obtained by taking the difference between the tier 1 capital ratio and the minimum requirement established by the banking authorities[11], the return on assets (ROA) that is

[10]The weights (0, 20, 50 or 100%) are ascribed according to Basel I accords. On and off balance sheet items have been summed when calculating total assets.

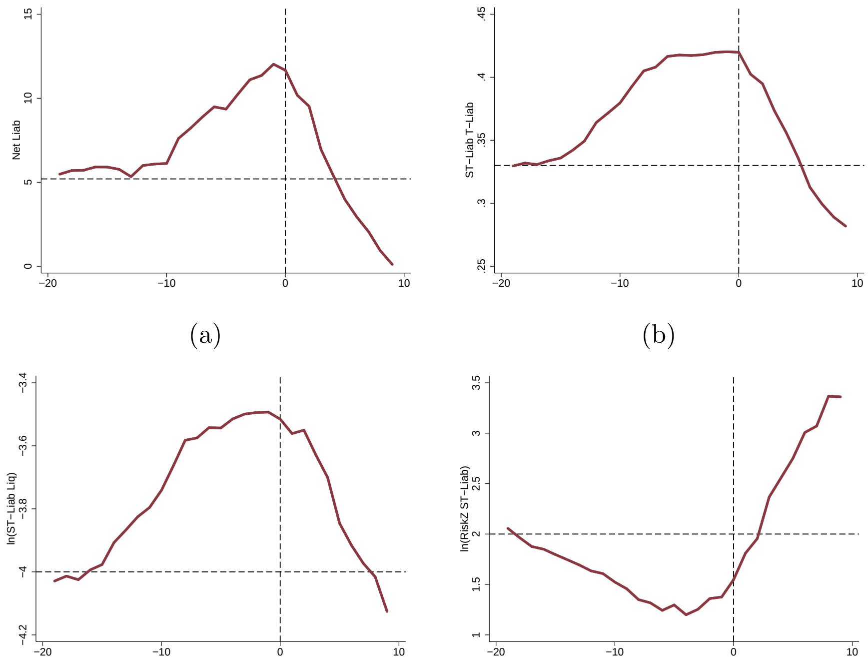
[11]In the period under analysis the minimum capital requirement was equal to 6%.

equal to the ratio of the income before income taxes and extraordinary items and other adjustments over total assets, the non-performing loans over total loans ($NPTL$), defined as loans that are past due at least 30 days or are on non-accrual basis, and the provisions for non-performing loans ($PROV$), by taking the ratio of loan loss provision over total loans.

4.3 Main facts at a glance

In the figure below, we report for several indicators of funding liquidity risk the behaviour of the banks that received the facilities for the period between -20 and $+10$ quarters around the first period they received the facilities for the first time. The graphs are quite informative: in all the cases banks decrease their funding liquidity risk positions once they received the facilities. This is true for the net liabilities (Figure 2.a), the ratio between short term liabilities over total liabilities (Figure 2.b) as well as for the log ratio between short term liabilities over liquidity (Figure 2.c). If we look at funding liquidity risk counterpart such as the fraction of risk free assets over short term liabilities (Figure 2.d), previous results are confirmed: once received the facility, banks increase this measure.

Figure 2: TAF participation and liability and liquidity banks behaviour (per-quarter averages)



(a) (b) (c) (d)

In Table 4, Section C of the Appendix the descriptive statistics of the variables employed in this study are reported.

We can distinguish along two dimensions. On the one hand, columns (5) and (11) refer to the average values of the variables before the beginning of the program and after its conclusion. On the other hand, columns (1), (3), (7) and (9) report the variables average values by distinguishing between banks that received TAF program facilities and the others banks in each of the two periods.

Focusing on funding liquidity risk indicators only, in order to test whether there are on average differences between the before and the after periods and between the TAF and the No TAF banks, ignoring potential selection bias, we run the following regression:

$$LIQ.\ RISK_{it} = \alpha + \beta_1 time + \beta_2 TAF_i + \beta_3 TAF_i \times time + \epsilon_{i,t} \quad (2)$$

In equation (2) the variable of interest, $Liq.Risk_{i,t}$, is regressed on a constant, a $time$ dummy variable that capture the time dimension (Before and After), a TAF group dummy variable in order to take into account whether a particular bank i belongs to the the TAF or to the No TAF group, and finally an interactive dummy variable, $TAF \times time$, that captures the difference in within groups differences.

In this way we are able to analyse the following four main cases even if we are basically interested in the coefficient β_3 that represents the difference in within groups differences:

Table 2: Different cases

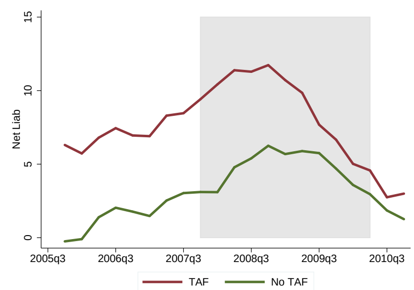
	TAF	No TAF	Diff.
After	$\alpha + \beta_1 + \beta_2 + \beta_3$	$\alpha + \beta_1$	$\beta_2 + \beta_3$
Before	$\alpha + \beta_2$	α	β_2
Diff.	$\beta_1 + \beta_3$	β_1	β_3

More precisely, we are interested in testing average difference within group across time and within time across groups. By fixing the bank group ("TAF" or "No TAF") we can test whether there are on average differences within the group before the beginning of the TAF program and after its conclusion. Furthermore, by fixing the time dimension (After or Before) we can test whether the two groups behave on average differently over time.

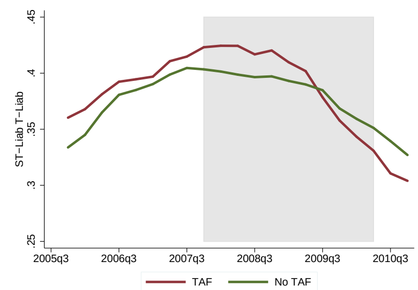
The results are reported in Section C, Table 5 of the Appendix. The main findings highlight that before the beginning of the program (2007:Q3), TAF banks report levels of funding liquidity risk higher than the other banks, and that these differences become smaller once the program is over (columns (1) and (2)). The other relevant result is that although all banks decrease their funding liquidity exposures, TAF banks did more. The only measure with respect to that No TAF banks behave better than TAF banks is $CASH$. Specifically, banks that do not receive the facilities increase CASH more than the other banks. An explanation of this result is that No TAF banks employ cash as a substitute of TAF facilities. In order to meet their liquidity needs they have to increase cash, given that they cannot benefit of these financial facilities aid.

A visual counterpart of previous findings are highlighted by the figures reported in graph 3. The results show that banks net liabilities between groups are quite different before the beginning of the program while this difference gets smaller after the end of the program. The same is true for the log of the ratio between short term liabilities and liquidity. Furthermore, for the ratio between net liabilities over total liabilities and the log of ratio between risk free assets and short term liabilities the patterns between the groups are reverted once the program is over.

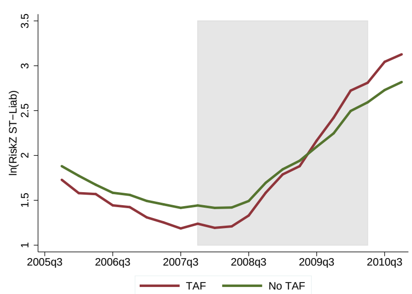
Figure 3: Liability and liquidity banks group behaviour (per-quarter-per-group averages)



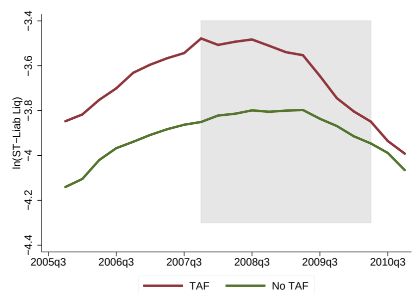
(a)



(b)



(c)



(d)

The descriptive analysis highlights that both groups of banks adjust the quantities that refer to liquidity risk. This is true by looking at liabilities and liquidity indicators. Moreover, in the majority of the cases TAF banks change these amount more than the No TAF banks. These changes imply as well that the ex ante differences across groups are smaller or disappear once the program is over.

Summing up, the banks that received the facilities were exactly the banks for whom the program has been designed.

Table 6 reports the pairwise correlation between the net liabilities, the log of the risk-free assets to short term liabilities ratio and the main controls employed in the econometric analysis of this study. Results show a negative correlation between net liabilities and $CASH$ ($-.304$) and $BUFFER$ ($-.28$), while the correlation with $PF\ RISK$, although it is negative is quite small around $-.013$. The correlation between net liabilities and the rest of the variables, $LIQUIDITY$ (.196), $TLOANS$ (.102), ROA (.027), $NPTL$ (.0514) and $PROV$ (.004) is positive even if the correlation coefficients show a lot of variability.
The log of the risk-free assets to short term liabilities ratio is positively correlated with $LIQUIDITY$ (.12), $CASH$ (.37), $NPTL$ and $PROV$ with correlation coefficients around .15, while it shows negative correlations with respect to portfolio risk ($-.36$), total loans ($-.28$), $BUFFER$ ($-.018$), and ROA ($-.156$).

4.4 The econometric model

In order to assess the impact of program facilities on banks liquidity risk we employ a treatment effects model. Measuring the impact of the TAF program, approximated by the TAF dummy (TAF), on liquidity risk by employing traditional OLS methods might lead to biased results. This is due to the fact that banks that received the facilities are ex ante different with respect to the rest of banks, so that we could incur in selection bias problems[12]. Therefore, we need to use a treatment effects model estimation in order to control for this source of potential selection bias. More specifically, we are interested in fitting the treatment-effects model

[12]Technical analysis of the selection bias issue is provided in Section A of the Appendix.

$$LIQ.\ RISK_{i,after} = TAF_i\beta_1 + x_i'\beta_2 + \xi_i \tag{3}$$

$$TAF_i^* = x_i'\pi_1 + z_i'\pi_2 + \nu_i \tag{4}$$

where

$$TAF_i = \begin{cases} 1 & \text{if } TAF_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

and where ξ_i and ν_i have a bivariate normal distribution with zero mean and covariance matrix

$$\begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}$$

In equation (3) the liquidity risk, $LIQ\ RISK$, depends at least in part on TAF, a binary endogenous regressor. Moreover, the latent variable defined in equation (4) determines the values of the binary variable TAF according to equation (4). The TAF dummy can be interpreted as a treatment indicator.

The baseline model is estimated by using Maximum Likelihood. In this way, it is possible to take into account the correlations between the two error terms at the cost of assuming that the error terms are bivariate normally distributed. Alternatively, the model can be estimated by a two–step approach, which has however the drawback that the system of equations is not estimated contemporaneously.

In the robustness part of this study we employ generated regressors. The usual estimations techniques to calculate the standard errors are incorrect so that they have been replaced by bootstrapped standard errors.

Finally, we have to deal with the identification restrictions. More specifically, the two sets of regressors we employed in the treatment and in the risk part of the system, equations (5) and (3) respectively, have to be different. The choice of the variables included in the two equations is discussed in the next section.

5 The Model

According to equations (3) and (5), the model takes the following form:

$$NETLIAB_{i,after} = \beta_0 + \beta_1 \, TAF_i + \beta_2 \, NETLIAB_i + \beta_3 \, CASH_i + \beta_4 \, ROA_i + \beta_5 \, BUFFER_i + \beta_6 \, Risk\_0_i + \beta_7 \, Risk\_20_i + \beta_8 \, Risk\_50_i + \beta_9 \, Risk\_100_i + \xi_i \tag{6}$$

$$TAF_i = \begin{cases} 1 & \text{if } TAF_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{7}$$

where the unobserved latent variable follows the specification below:

$$TAF_i^* = \pi_0 + \pi_1 \, NETLIAB_i + \pi_2 \, CASH_i + \nu_i \tag{8}$$

As documented in Section 4.4 in order to deal with the potential selection bias we adopt a simultaneous equation approach. Specifically, we fit a treatment effects model that includes two parts: a probit model to capture the probability of obtaining the facilities and a classical linear regression to assess the impact of the TAF program on liquidity risk. The two equations are estimated simultaneously by using Maximum Likelihood.

The explanatory variables in equations (6) and (8) are measured prior to the beginning of the program, by the value of the variables in 2007.Q3. The dependent variable in equation (6) has been measured in 2010.Q3, once the TAF program was over.

As previously discussed in subsection 3.1, the aim of the TAF program was to inject liquidity in the inter bank credit market by providing facilities to banks in financial distress. Moreover, this result had to be achieved by limiting potential "stigma" effect related with this type of financial aid. Therefore, the way of providing facilities had been based on an auction system. It follows that the goal of the auction was not to maximize Fed profits but to reduce at most the potential "stigma" effect. All these considerations convinced us to model the participation equation (i.e. equation (8)) by taking into account funding liquidity distress indicators, and disregarding those variables measuring banks competitiveness, useful in a normal auction system for winning the auction.

Equation (6) takes into account the relationship between the ex post liquidity risk level, approximated in the baseline model by $NET\ LIAB$ level and the TAF dummy variable, controlling for a set of covariates. Among them we employ the ex ante value of the dependent variable with the aim of capturing the autoregressive component of the liquidity risk process. Specifically, we expect to find a positive autoregressive relationship.

Moreover, the baseline model includes as well $CASH$, the level of $BUFFER$ and the ROA. By including the cash over total assets ratio we want to capture potential liquidity distress associated with banks liquidity needs. The higher the level of cash the lower is the ex post level of liquidity risk.

$BUFFER$ is defined as the difference between the tier 1 capital ratio and the minimum requirement established by the banking authorities. Its inclusion in the specification is useful for assessing the impact of capital cushions on the level of liquidity risk. More precisely, we expected that higher buffer implies that banks are more prone to adopt more aggressive investment strategy. It follows that banks face an increase in risk, so that higher buffer levels are expected to lead to higher level of liquidity risk.

Return on assets is a measure of the return of the investment. High investment return level is a proxy of the efficiency of the investment, so that its effect on the funding liquidity risk might be negative. Finally, in the baseline model we also include the different type of assets depending on their riskiness consistently with Basel I accords. In this way it is possible to assess the effects of portfolio composition on the level of funding liquidity risk. We do not have a priori expected sign for the effect of these variables on the level of funding liquidity risk.

Depending on the specification, in equation (6), we also include $NPTL$ and $PROV$ in order to capture the impact on funding liquidity risk of current and expected future distress due to bad loans on liquidity risk. More precisely, on the one hand, higher current level of $NPTL$ can induce banks to take in the future more prudent investment strategies. Therefore, the ex post funding liquidity risk decreases for higher values of $NPTL$. On the other hand, higher current level of expected future loan losses may positively affect the level of ex post funding liquidity risk. It follows that, $PROV$ is expected to positively affect the dependent variable in equation (6).

Moreover, we also include the ratio of total loans over total assets and the relative importance of the different type of loans, in order to capture loans composition effect on the level of funding liquidity risk. As for the asset types, we do not have a priori expected sign for the effect of these two variables on the level of funding liquidity risk.

Finally, once controlled for selection bias, the TAF dummy variable, which takes value 1 if a bank received at least once the facilities and 0 otherwise, is expected to have a negative impact on ex post liquidity risk. A potential argument in favour of the relationship described above is that banks with liquidity needs that obtained the funds were under strict control of the regulatory authorities so that they were forced to adopt a behaviour, in term of funding liquidity risk, more virtuous than that exhibited by the rest of the banks.

Table 3: Expected signs

	Treatment equation	**Risk equation**
NET LIAB	+	+
LIQUIDITY	−	−
CASH	−	−
BUFFER	···	+
NPTL	···	−
ROA	···	+/−
PROV	···	+
PF RISK	···	+/−
TLOANS	···	+/−
TAF	···	−

6 Results

In this section we present the baseline results as well as the robustness checks. Finally, we discuss the main implications of our findings from a policy view point.

6.1 Baseline

The baseline results, obtained by Maximum Likelihood estimation, are reported in Table 7, Section C of the Appendix. In column (1) the model has been estimated in its light version, excluding asset type variables. In column (2) we added $PROV$ and $NPTL$ in order to take into account current and expected future losses due to non performing loans. Column (3) is a variation of column (1) where the baseline model has been augmented by including total loans over total assets as well as different loan types as a share of total loans. In columns (4) and (5) we include aggregate portfolio risk and asset risk types, respectively. In all these cases the modifications refer only to the risk equations, while the treatment equation does not change. Finally, column (6) is a variation of column (1) where we replace $CASH$ by $LIQUIDITY$ in both the risk and the treatment equation.

Independently of the specification taken into account, the main results do not change.

Specifically, focusing on the TAF equation, the results highlight strong regularities. Ex ante higher values of liquidity risk positively affect the probability of receiving TAF facilities. Higher levels of cash or liquidity decrease the probability of obtaining the loans.

Analysing the risk equation several regularities arise independently on the specifications chosen. First, regardless of the specification, the coefficient of the TAF dummy is always statistically significant. It affects negatively the ex post level of the liquidity risk. This effect is not only statistically significant, but it is also economically substantial. The fact of receiving TAF loans decreases the liquidity risk level between 9 and 16 points over a maximum of 100. Moreover, we also find that the autoregressive component has a positive and significant impact on the dependent variable. Higher levels of cash decrease the ex post value of liquidity risk, while liquidity has no impact on the dependent variable.

Another robust result refers to the positive impact of capital buffer on the liquidity risk. The higher the margin of capital above capital requirements the higher is the level of funding liquidity risk. This finding confirms our intuition about the impact of $BUFFER$ on the dependent variable. ROA shows always a coefficient statistically smaller than zero. As expected higher level of ROA decreases the level of funding liquidity risk.

Column (2) shows that non performing loans and provisions for future loan losses are not statistically significant. Therefore, we can conclude that current and expected loan losses are not affecting funding liquidity risk. Columns (3) highlights that total loans over total assets and the different loans components area statistically significant. Specifically, the higher the total loans over total assets the lower the funding liquidity risk, while the fraction of different loan types positively impact on the dependent variable.

Columns (4) and (5) show that, on the one hand, portfolio risk is statistically not significant, while the different assets categories, depending on their risk level, are always statistically significant. All but the zero risky assets variable positively affect the funding liquidity risk.

According to the specification of the model we are able to test whether we are facing a selection bias, implying that, if not controlled, the TAF dummy would capture spurious effects. Formally, this information is provided by the estimated coefficient on lambda. In all the cases, we can reject the null hypothesis that the estimated coefficient is zero (see the correspondent χ^2). Therefore, it follows that there exists a selection bias that we have to control for.

6.2 Robustness

We perform a series of robustness checks, by using as a baseline the specification reported in column (1) of Table 8, Section C of the Appendix. Columns (2) to (3) show the regression results when we relax some of the assumption we made in the baseline regressions. In particular, column (2) displays the result based Maximum Likelihood estimation, but reporting bootstrap standard errors, while in column (3) we report the results that refer to the two-step estimation, once relaxed the joint normal distribution assumption about the error terms. The results are not substantially different from the baseline model reported in column (1).

Then, we change the sample period for computing the ex ante averages of our variables. In column (4) we use as ex ante period a short-run average (between 2006.Q3 and 2007.Q3) while in column (5) we employ a long-run average (between 2001.Q1 and 2007.Q3). In both cases changing the ex ante period does not qualitatively affect our results. The estimate of the TAF variable remains negative and statistically significant.

Since our sample includes all commercial banks that handed in Call reports, and only a small fraction of those banks received TAF funding, we face a potential problem from the uneven distribution of the number of banks in the two groups. In order to alleviate this problem we run a Monte Carlo simulation by including all banks that participated to the program but randomly choosing only a subset of banks that did not receive TAF funding. Each estimation is based on about 1050 observations. As column (6) of Table 8 shows, the results are largely unvaried compared to our benchmark case. In Figure 4, Section B of the

Appendix, the distribution of the estimate of the TAF variable obtained from the Monte Carlo simulation is provided, as well as the bounds of the 95% confidence interval.

Our result could suffer from omitted variable bias due to the fact that other events occurred contemporaneously to TAF program and they have not been explicitly taken into account. In particular, one relevant episode was the failure of Lehman Brothers in 2008.Q3. In order to neutralize the potential "Lehman effect" we drop from our sample banks that had more of their credit lines co-syndicated with Lehman Brothers, as defined by Ivashina and Scharfstein (2010). The results, reported in columns (7) of Table 8, document that the coefficient on TAF is statically significantly different from zero and it has the expected negative sign. Therefore, we can conclude that the results are not driven by "Lehman effect".

Throughout our paper we have used net liabilities as the measure for bank liquidity riskiness. The literature suggests various other measures of liquidity risk, which include risk free assets to short term liabilities ratio, the ratio between short term liabilities over total liabilities, the short term liabilities to total assets ratio, the short term assets to short term liabilities and finally the ratio between the short term liabilities over liquidity. Table 9, Section C of the Appendix compares the estimation results when different measures of liquidity risk are employed.

Column (1) reports the baseline results using net liabilities as a proxy for liquidity risk. Columns (3), (4) and (5) show the results when the ratio between short term liabilities over total liabilities, the short term liabilities to total assets ratio and the ratio between the short term liabilities over liquidity are employed as dependent variables. The estimation results for the TAF dummy in the risk equation are negative and statistically significant. Moreover, also the autoregressive component is statistically significant.

We also proceed to estimate the econometric model by using two "counter parts" of liquidity risk as dependent variable. Specifically, column (2) shows the estimation results when we use the log of the ratio between risk-free asset over short term liabilities. The estimation results for TAF are positive and statistically significant. Moreover, also the autoregressive component is statistically significant. The results do not change if we employ instead the log of the ratio between short term assets over short term liabilities. The main finding is that once controlled for potential endogeneity, receiving TAF facilities increase the two ratios, therefore also in this case the ex post liquidity risk decreases.

6.3 Discussion

We showed that the program was successful in detecting banks in liquidity needs and, at the same time, it helped in decreasing ex post liquidity risk. This implies that TAF-like programs are recommended during situations similar to the last crisis. Moreover, it also follows that the Fed behaved as lender of last resort, achieving its goal to inject liquidity in the inter bank credit market.

One relevant result of our study is that even if we control for initial liquidity features, banks that received facilities reduce their funding liquidity risk more than the rest of the banks. If Fed was behaving only as a lender of last resort, basically lending money to banks solvent but temporary illiquid, we would not be able to observe such effect. Our results suggest that something else happened. Specifically, we claim that there is a positive externality related to the fact of receiving the facilities that has not be taken into account. A potential argument in favour of the relationship described above is that banks with liquidity needs that obtained the funds were under strict control of the regulatory authorities so that they were forced to adopt a behaviour, in term of funding liquidity risk, more virtuous than that exhibited by the rest of the banks.

If TAF-like programs are the tool to implement during crisis period, our contribution provides some insights also about what to do in order to avoid situations such as the last financial crisis. In particular, the results highlight the positive relationship between banks capital caution and the level of funding liquidity risk. It follows that by observing only buffer is not sufficient to judge banking financial risk.

Therefore, if regulatory authorities treat capital caution as the only element for controlling general banking financial soundness, they are missing a relevant component of the risk related to liability term structure. In this perspective our contribution provides empirical justification to those arguments in favour of the introduction of measures for liquidity risk in financial regulation.

7 Conclusion

During the last financial crisis the Federal Reserve promoted several extraordinary actions, including the creation of a number of new facilities for auctioning short-term credit, with the general aim of sustaining the financial sector and of ensuring that financial institutions have adequate access to liquidity. One of these program has been the Term Auction Facility (TAF).

The objective of this study was two-fold: on the one hand, we analysed the characteristics of the banks that received TAF facilities and we compared them to those of the other banks; on the other hand, we assess the impact of TAF facilities on banks' liquidity risk. By acquiring this information is relevant for assessing the strength of the program in targeting banks in liquidity needs, for understanding its effectiveness in reaching its goals of reducing liquidity risk, for identifying its weaknesses and strengths, and for measuring potential externalities associated with its implementation.

In order to avoid potential selection biases, we use a treatment effects model. The probability of obtaining TAF program facilities is regressed on a set of variables, measured before the beginning of the TAF program, in order to capture funding liquidity distress. Simultaneously, the impact of TAF facilities on banks liquidity risk, posterior to the end of the program, has been measured.

The results suggest that, on average, banks that obtained program facilities show lower short term assets over short term liabilities ratio, and higher net liabilities, as well as higher short term liabilities over liquidity ratio. Finally, these banks report liquidity measures lower than those of the other banks.

Moreover, it has been found that banks that obtained at some point TAF facilities, exhibit smaller ex post liquidity risk as well as that ex ante liquidity risk positively affects the probability of receiving program facilities. Several robustness checks confirm the main results.

Our results sustain the opinion that Fed properly designed the program so that the "target" banks were finally those that obtained the facilities. Moreover, they also support the view point such that the program was able to decrease the liquidity risk at bank level, confuting the criticisms about the impact of TAF program on liquidity risk.

One limitation of our contribution refers to the composition of the dataset employed. Specifically, we cannot distinguish between banks that participated and did not obtain the facilities from those banks that did participate at all. In further research it could be interesting to focus only on those banks that bid in the auctions of the program and perform a natural experiment exercise. Another potential application of our results could be to analyse the behaviour of the banks towards risk controlling for the amount of facilities received and the number of times that the bank participated and obtained facilities. This would allow to capture potential moral hazard behaviour of banks associated with the experience of past auctions.

Finally, another application could be to assess the impact of TAF program on banks balance–sheet as we already measured, at least in a primary version, in a companion paper.

References

[1] O. Armantier, E. Ghysels, AsaniSarkar, and J. Shrader, "Stigma in financial markets: evidence from liquidity auctions and discount window borrowing during the crisis," tech. rep., 2011.

[2] O. Armantier, S. Krieger, and J. McAndrews, "The federal reserve's term auction facility," *Current Issues in Economics and Finance*, no. Jul, 2008.

[3] M. Bruche and J. Suarez, "Deposit insurance and money market freezes," *Journal of Monetary Economics*, vol. 57, pp. 45–61, January 2010.

[4] M. K. Brunnermeier and L. H. Pedersen, "Market liquidity and funding liquidity," *Review of Financial Studies*, vol. 22, no. 6, pp. 2201–2238, 2009.

[5] A. C. Cameron and P. K. Trivedi, *Microeconometrics Using Stata, Revised Edition*. Stata Press books, StataCorp LP, 2010.

[6] M. Campello, E. Giambona, J. R. Graham, and C. R. Harvey, "Liquidity management and corporate investment during a financial crisis," Working Paper 16309, National Bureau of Economic Research, August 2010.

[7] M. Campello, J. Graham, and C. R. Harvey, "The real effects of financial constraints: Evidence from a financial crisis," Working Paper 15552, National Bureau of Economic Research, December 2009.

[8] J. H. E. Christensen, J. A. Lopez, and G. D. Rudebusch, "Do central bank liquidity facilities affect interbank lending rates?," tech. rep., 2009.

[9] M. Drehmann and K. Nikolaou, "Funding liquidity risk: Definition and measurement," Working Paper Series 1024, European Central Bank, 2009.

[10] R. Huang and L. Ratnovski, “The dark side of bank wholesale funding,” tech. rep., 2009.

[11] V. Ivashina and D. Scharfstein, “Bank lending during the financial crisis of 2008,” *Journal of Financial Economics*, vol. 97, pp. 319–338, September 2010.

[12] J. McAndrews, A. Sarkar, and Z. Wang, “The effect of the term auction facility on the london inter-bank offered rate,” tech. rep., 2008.

[13] F.-L. Michaud and C. Upper, “What drives interbank rates? evidence from the libor panel,” *BIS Quarterly Review*, March 2008.

[14] S. Puddu and A. Waelchli, “Taf balance–sheets,” tech. rep., March 2011.

[15] J. B. Taylor and J. C. Williams, “A black swan in the money market,” Working Paper 13943, National Bureau of Economic Research, April 2008.

[16] J. Taylor and J. Williams, “Further results on a black swan in the money market,” tech. rep.

[17] D. L. Thornton, “The effectiveness of unconventional monetary policy: the term auction facility,” tech. rep., 2010.

[18] T. Wu, “On the effectiveness of the federal reserve’s new liquidity facilities,” tech. rep., 2008.

Appendices

A The selection bias issue

The selection bias issue occurs when one or more explanatory variables are correlated with the residuals. Therefore, these covariates are capturing "pure" effect that can be ascribed directly to them, but at the same time they capture as well the effect referring to the residual term. As a consequence we cannot interpret the estimated coefficient of these variables as their effect on the dependent variable.[13] In the case analysed in this paper if banks participate to TAF program because they have an unobservable higher propensity to risk, then TAF participation effect on risk could be overstated.

Assume that a generic econometric specification takes the following form:

$$Y = \alpha + \beta_1 X + \beta_2 D + \xi$$

where D is a dummy variable if individual i attends the program and zero otherwise. Assume that the fact of attending the program is affected by an unobservable characteristic. Assume first that the bias problem is not taken into account and a linear regression is estimated. The expected values of Y if $D = 1$ and when $D = 0$ take the following forms:

$$E(Y|D = 1) = \alpha + \beta_1 X + \beta_2 + E(\xi|D = 1) \tag{9}$$

and

$$E(Y|D = 0) = \alpha + \beta_1 X + E(\xi|D = 0) \tag{10}$$

respectively. Therefore the effect on the average value of Y is given by

[13]See also Cameron and Trivedi (2010)

$$E(Y|D=1) - E(Y|D=0) = \beta_2 + E(\xi|D=1) - E(\xi|D=0) \tag{11}$$

The estimated coefficient is capturing both the "pure" effect $\widehat{\beta}_2$ that can be ascribed to the fact of attending the program as well as the effects related to unobservable features $E(\xi|D = 1) - E(\xi|D = 0)$. One way to solve for this potential issue is to estimate a treatment effect model. They are based on the simultaneous estimation of two regressions.

On the one hand, a probit model is estimated in order to compute the predicted probability of participating to the program controlling for a set of potential explanatory variables.

$$D^* = Z\theta + \epsilon$$

where D^* is a latent variable, Z is the vector of the observable features affecting the fact of participating and ϵ are the residual. We assume that the error terms of the probit and the linear model, ϵ and ξ, respectively are bivariate normally distributed with zero mean and covariance matrix

$$\begin{bmatrix} 1 & \\ \rho\sigma_\xi & \sigma_\xi \end{bmatrix}$$

Finally,

$$D = \begin{cases} 1 & \text{if } D^* > 0 \\ 0 & \text{if } D^* \leq 0 \end{cases}$$

It follows that

$$P(D=1) = \Phi(Z\theta) \quad \text{and} \quad P(D=0) = 1 - \Phi(Z\theta)$$

and from the joint density of the bivariate normally distributed variables, equations (9) and

(10) can be written as

$$E(Y|D=1) = \alpha + \beta_1 X + \beta_2 + \rho\sigma_\xi \frac{\phi(Z\theta)}{\Phi(Z\theta)}$$

$$E(Y|D=0) = \alpha + \beta_1 X - \rho\sigma_\xi \frac{\phi(Z\theta)}{1-\Phi(Z\theta)}$$

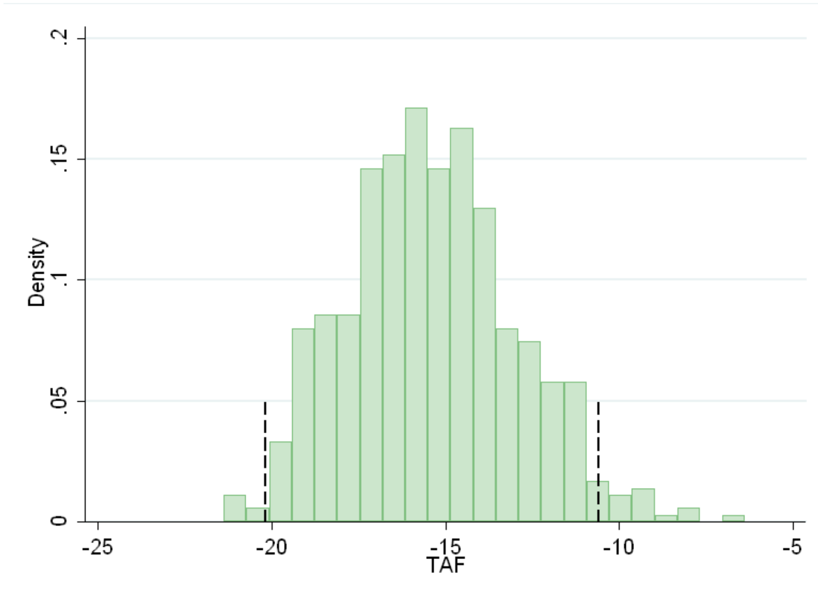
The average treatment effect is therefore the difference,

$$E(Y|D=1) - E(Y|D=0) = \beta_2 + \rho\sigma_\xi \frac{\phi(Z\theta)}{\Phi(Z\theta)[1-\Phi(Z\theta)]} \tag{12}$$

where ρ is the correlation between the two error terms and σ_ξ is the noise term standard error of the linear regression. By using the treatment effect model we are able to capture the effects of unobservable features captured by the treatment variable and therefore to exactly measure the "pure" effect of participating to the program. The "cost" of adopting this approach is the strong assumption about the distribution of the error terms. An alternative approach that does not require previous assumption is to run a two-step estimation, computing robust standard error.

B Monte Carlo simulation

Figure 4: TAF estimated coefficient obtained from a Monte Carlo simulation



In order to alleviate the potential problem of the uneven distribution of TAF and Non-TAF banks, we run a Monte Carlo simulation. In each iteration, the sample includes all TAF banks and a randomly chosen subset of Non-TAF banks.

The graph in Figure 4 shows the distribution of the estimate of TAF facilities as well as the bounds of the corresponding confidence interval at 95% obtained by repeating 1000 times the estimation and by using a sample of around 1050 observation randomly. Before the estimation we check whether the mean of all used variables of the chosen sub-sample are within a narrow band around the mean of the entire sample (we use 0.2 times the standard deviation as threshold).

C Tables

Table 4: Summary statistics

	No TAF		Before TAF		All		No TAF		After TAF		Total	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Liquidity and Liabilities	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
NET_LIAB_ASS	4.286	18.11	8.326	19.14	4.434	18.17	2.676	15.57	2.793	15.64	2.680	15.57
PF_RISK_0_LIAB	1.427	1.277	1.201	1.613	1.419	1.291	2.728	1.368	3.045	1.428	2.740	1.372
ST_LIAB_TLIAB	.00404	.00131	.00413	.00142	.00404	.00131	.00338	.00119	.00311	.00127	.00337	.00119
ST_LIAB_TASS	-5.735	.460	-5.760	.481	-5.736	.461	-5.906	.444	-6.037	.498	-5.910	.446
ST_ASS_LIAB	4.408	.749	4.252	.849	4.402	.753	4.453	.688	4.442	.800	4.453	.692
ST_LIAB_LIQ	-3.858	1.111	-3.547	1.279	-3.847	1.119	-3.985	1.173	-3.936	1.165	-3.984	1.172
LIQUIDITY	.208	.139	.158	.118	.206	.138	.206	.145	.173	.124	.205	.144
CASH	.0377	.0397	.0288	.0355	.0374	.0395	.0841	.0778	.0636	.0619	.0833	.0774
Other banks features												
BUFFER	.0541	.0654	.0476	.0835	.0538	.0662	.0424	.0411	.0371	.0316	.0422	.0408
SIZE	11.90	1.248	14.08	2.136	11.98	1.354	12.05	1.215	14.15	2.086	12.13	1.319
ROA	.00840	.0102	.0102	.00976	.00846	.0102	.00407	.0116	.00132	.0162	.00397	.0118
NPTL	.0239	.0245	.0173	.0165	.0236	.0243	.0448	.0464	.0560	.0487	.0452	.0466
PROV	.00142	.00353	.00197	.00318	.00144	.00351	.00459	.00678	.0101	.0108	.00480	.00705
Loans												
TLOANS	.645	.149	.681	.143	.646	.149	.616	.142	.656	.133	.618	.142
CILOANS	.148	.106	.176	.130	.149	.107	.136	.0979	.158	.114	.137	.0986
RTESTLOANS	.685	.194	.700	.202	.686	.194	.710	.189	.720	.209	.710	.189
INDIVLOANS	.0768	.0902	.0731	.145	.0767	.0928	.0663	.0880	.0753	.178	.0667	.0930
AGRILOANS	.0734	.126	.0174	.0543	.0714	.124	.0731	.125	.0183	.0560	.0711	.123
Portfolio Assets												
PF_RISK	.691	.125	.758	.115	.694	.126	.656	.116	.703	.108	.658	.116
PF_RISK_0	.0260	.0488	.0250	.0615	.0260	.0493	.0759	.0831	.0850	.0878	.0762	.0833
PF_RISK_20	.251	.143	.188	.118	.249	.142	.224	.139	.171	.105	.222	.139
PF_RISK_50	.162	.120	.133	.0965	.161	.119	.171	.116	.134	.0844	.170	.115
PF_RISK_100	.561	.170	.655	.154	.565	.171	.530	.156	.610	.137	.533	.156
Observations	7520		271		7791		6832		252		7084	

Before period refers to 2007.Q3, After period refers to 2010.Q3.

Table 5: Average differences tests: Before and After

Liabilities and Liquidity	Before	After	No TAF	TAF	Diff in Diff
	(1)	(2)	(3)	(4)	(5)
NET_LIAB_ASS	5.279***	1.723*	-1.304***	-4.860***	-3.556**
	(1.143)	(1.034)	(0.301)	(1.512)	(1.542)
PF_RISK_0_ST_LIAB	-0.144	0.384***	1.282***	1.810***	0.528***
	(0.096)	(0.095)	(0.023)	(0.133)	(0.135)
ST_ASS_LIAB	-0.165***	-0.040	0.034**	0.160*	0.125
	(0.055)	(0.062)	(0.015)	(0.082)	(0.083)
ST_ASS	1.984***	1.976***	0.037	0.029	-0.008
	(0.131)	(0.130)	(0.024)	(0.183)	(0.185)
ST_LIAB	2.199***	2.030***	0.001	-0.168	-0.169
	(0.137)	(0.135)	(0.025)	(0.191)	(0.193)
LIQUIDITY	-0.049***	-0.032***	0.002	0.019*	0.017
	(0.008)	(0.008)	(0.003)	(0.011)	(0.011)
CASH	-0.016***	-0.031***	0.046***	0.032***	-0.015***
	(0.002)	(0.004)	(0.001)	(0.004)	(0.004)
ST_LIAB_TLIAB	0.000	-0.000**	-0.001***	-0.001***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ST_LIAB_TASS	-0.071	-0.157***	-0.174***	-0.261***	-0.086
	(0.043)	(0.048)	(0.014)	(0.063)	(0.065)
ST_LIAB_LIQ	0.209**	-0.030	-0.159***	-0.398***	-0.239**
	(0.082)	(0.081)	(0.023)	(0.113)	(0.116)

The results are based on the estimation of eq. (2), according to table 2.

Table 6: Correlation Matrix

	NET_LIAB_ASS	PF_RISK_0_LIAB	LIQUIDITY	CASH	PF_RISK	TLOANS	BUFFER	ROA	NPTL	PROV
NET_LIAB_ASS	1									
PF_RISK_0_LIAB	-.228	1								
LIQUIDITY	.156	.243	1							
CASH	-.208	.157	-.0258	1						
PF_RISK	-.0177	-.380	-.721	-.254	1					
TLOANS	.134	-.333	-.797	-.250	.818	1				
BUFFER	-.339	.0869	.0170	.124	-.190	-.296	1			
ROA	.0384	-.00107	.0520	-.0159	.111	.128	-.362	1		
NPTL	.0468	-.0118	.0161	.00203	-.0256	.0178	-.0862	-.0498	1	
PROV	-.0136	-.105	-.186	-.0337	.183	.137	.0803	-.301	.265	1

Table 7: Baseline model

	(1)	(2)	(3)	(4)	(5)	(6)
Risk equation	Dependent variable: LIQ_RISK_a					
LIQ_RISK	.550***	.548***	.527***	.549***	.543***	.561***
	(.012)	(.012)	(.012)	(.012)	(.013)	(.012)
CASH	-28.553***	-15.178***	-16.833***	-29.492***	-30.106***	
	(4.504)	(5.629)	(5.728)	(4.646)	(4.805)	
BUFFER	11.347***	23.608***	25.081***	10.798***	11.273***	5.605*
	(2.879)	(3.496)	(3.411)	(2.873)	(2.816)	(2.905)
ROA	-.174	-1.090***	-.792***	-.174	-.173	-.218*
	(.108)	(.281)	(.276)	(.107)	(.105)	(.120)
TAF	-18.110***	-13.735***	-11.823***	-17.948***	-17.320***	-15.137***
	(1.890)	(2.610)	(2.671)	(1.900)	(1.929)	(2.587)
PROV		-.436				
		(.748)				
NPTL		24.328***				
		(7.925)				
TLOANS			-4.313***			
			(1.359)			
CILOANS			21.498***			
			(5.929)			
RESTLOANS			31.788***			
			(5.534)			
INDIVLOANS			27.837***			
			(5.968)			
AGRILOANS			20.051***			
			(5.599)			
PF_RISK				-2.041		
				(1.703)		
PF_Risk_0					-11.699**	
					(4.805)	
PF_Risk_20					4.378***	
					(1.344)	
PF_Risk_50					4.818***	
					(1.195)	
PF_Risk_100					.977*	
					(.520)	
LIQUIDITY						-1.843
						(1.443)
Constant	2.043***	1.093**	-24.384***	3.528***		1.504***
	(.264)	(.518)	(5.531)	(1.282)		(.363)
TAF equation	Dependent variable: TAF					
LIQ_RISK	.008***	.006***	.006***	.008***	.008***	.010***
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
CASH	-4.389***	-3.944**	-3.976**	-4.360***	-4.380***	
	(1.385)	(1.578)	(1.640)	(1.380)	(1.392)	
LIQUIDITY						-1.282***
						(.229)
Constant	-1.702***	-1.712***	-1.711***	-1.703***	-1.702***	-1.632***
	(.052)	(.057)	(.059)	(.052)	(.052)	(.048)
Observations	7790	7672	7672	7790	7790	7790
rho	.486	.377	.322	.485	.473	.396
lambda	6.657	4.902	4.092	6.641	6.449	5.422
	(.828)	(1.161)	(1.192)	(.829)	(.842)	(1.137)
χ^2	50.26	15.42	10.56	49.95	46.39	19.47

Robust s.e. in parentheses. *** = $p < .01$, ** = $p < .05$, * = $p < .1$

Table 8: Different methodologies

	(1) MLE robust	(2) MLE bootstrap	(3) Two-Step	(4) Short average	(5) Long average	(6) Monte Carlo	(7) Lehman
Risk equation	Dependent variable: *LIQ_RISK*						
LIQ_RISK	.543***	.543***	.557***	.541***	.587***	.564***	.542***
	(.013)	(.013)	(.011)	(.002)	(.003)	(0.037)	(.0127)
CASH	-30.106***	-30.106***	-32.958***	-35.021***	-33.481***	-32.246**	-30.04***
	(4.805)	(4.457)	(3.201)	(1.350)	(1.524)	(13.209)	(4.804)
BUFFER	11.273***	11.273***	11.333***	18.693***	22.423***	18.105**	11.21***
	(2.816)	(2.741)	(1.834)	(.580)	(.590)	(7.534)	(2.817)
ROA	-.173	-.173	-.168***	-76.222***	-112.585***	-.582**	-.173
	(.105)	(.201)	(.035)	(4.891)	(5.977)	(.283)	(.105)
PF_Risk_0	-11.699**	-11.699***	-10.827***	-14.944***	-16.711***	-1.772	-11.65**
	(4.805)	(4.460)	(3.050)	(.965)	(1.009)	(9.228)	(4.81)
PF_Risk_20	4.378***	4.378***	5.739***	8.767***	7.778***	6.619*	4.37***
	(1.344)	(1.337)	(1.060)	(.172)	(.270)	(3.559)	(1.345)
PF_Risk_50	4.818***	4.818***	6.302***	6.286***	11.140***	8.491**	4.82***
	(1.195)	(1.285)	(1.326)	(.208)	(.204)	(3.419)	(1.19)
PF_Risk_100	.977*	.977*	2.390***	-.791***	.078	4.509***	.95*
	(.520)	(.589)	(.604)	(.097)	(.109)	(1.707)	(.520)
TAF	-17.320***	-17.320***	-55.760***	-19.309***	-19.910***	-17.897***	-17.04***
	(1.929)	(1.966)	(10.701)	(.233)	(.218)	(3.227)	(1.97)
TAF equation	Dependent variable: *TAF*						
LIQ_RISK	.008***	.008***	.005***	.009***	.009***	.009***	.008***
	(.002)	(.002)	(.001)	(.000)	(.000)	(.003)	(.002)
CASH	-4.380***	-4.380**	-3.809***	-7.173***	-7.159***	-5.092***	-4.3***
	(1.392)	(1.726)	(1.038)	(.594)	(.496)	(1.726)	(1.4)
Constant	-1.702***	-1.702***	-1.716***	-1.571***	-1.5***	-0.5***	-1.71***
	(.052)	(.060)	(.044)	(.019)	(.019)	(.072)	(.052)
Observations	7790	7790	7790	7790	7790	1050	7784
rho	.473	.473	1	.595	.608	0.611	.4647
lambda	6.449	6.449	23.37	7.896	8.147	9.226	6.33
	(.842)	(.702)	(4.697)	(.965)	(924)	(2.032)	(.85)
χ^2	21.43	21.43				20.075	19.94

Robust s.e. in parentheses. *** = $p < .01$, ** = $p < .05$, * = $p < .1$

Table 9: Different dependent variables

Risk equation	(1) LIQ_RISK_a	(2) $PF\_RISK\_0\_LIAB\_a$	(3) $ST\_LIAB\_TLIAB\_a$	(4) $ST\_LIAB\_TASS\_a$	(5) $ST\_ASS\_LIAB\_a$	(6) $ST\_LIAB\_LIQ\_a$
CASH	-30.106***	-.581	.063*	-.112	.985***	1.509***
	(4.805)	(.466)	(.036)	(.226)	(.381)	(.425)
BUFFER	11.273***	-.515	.098***	1.076***	-1.312***	1.669***
	(2.816)	(.352)	(.022)	(.136)	(.208)	(.269)
ROA	-.173	-.025	-.000	-.029***	.029*	-.037**
	(.105)	(.024)	(.001)	(.006)	(.016)	(.016)
PF_Risk_0	-11.699**	2.085***	.058***	-2.121***	1.787***	-1.610***
	(4.805)	(.564)	(.021)	(.307)	(.299)	(.283)
PF_Risk_20	4.378***	1.850***	.095***	-2.124***	1.752***	-1.114***
	(1.344)	(.116)	(.009)	(.237)	(.116)	(.211)
PF_Risk_50	4.818***	1.319***	.042***	-2.215***	1.600***	-1.063***
	(1.195)	(.112)	(.009)	(.233)	(.088)	(.137)
PF_Risk_100	.977*	2.332***	.103***	-1.985***	1.976***	-.733***
	(.520)	(.060)	(.006)	(.230)	(.128)	(.085)
LIQ_RISK	.543***					
	(.013)					
TAF	-17.320***	.769***	-.059***	-.600***	.248**	-.311***
	(1.929)	(.165)	(.010)	(.108)	(.102)	(.070)
PF_RISK_0_LIAB		.463***				
		(.025)				
ST_LIAB_TLIAB			.626***			
			(.011)			
ST_LIAB_TASS				.667***		
				(.041)		
ST_ASS_LIAB					.587***	
					(.026)	
ST_LIAB_LIQ						.806***
						(.029)
TAF equation			Dependent variable: TAF			
CASH	-4.380***	-3.840**	-4.323**	-4.512***	-3.879**	-4.049**
	(1.392)	(1.842)	(1.829)	(1.595)	(1.770)	(1.762)
LIQ_RISK	.008***					
	(.002)					
PF_RISK_0_LIAB		-.047*				
		(.026)				
ST_LIAB_TLIAB			.164			
			(.223)			
ST_LIAB_TASS				.314**		
				(.156)		
ST_ASS_LIAB					-.122***	
					(.040)	
ST_LIAB_LIQ						.111***
						(.024)
Constant	-1.702***	-1.606***	-1.733***	.195	-1.149***	-1.249***
	(.052)	(.064)	(.123)	(.910)	(.175)	(.106)
Observations	7790	7334	7658	7658	7658	7378
rho	.473	-.115	.0928	.560	-.120	.0556
lambda	6.449	-.144	.00893	.210	-.0657	.0458
	(.842)	(.0610)	(.00316)	(.0533)	(.0390)	(.0134)
χ^2	46.39	5.513	7.949	11.34	2.817	11.79

Robust s.e. in parentheses. *** = $p < .01$, ** = $p < .05$, * = $p < .1$