The Federal Reserve Liquidity Programs and Bank Performance

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Abstract

Using financial statements of U.S. bank holding data, we study the relation between bank performance and participation in the Federal Reserve liquidity programs during 2007Q1-2012Q3. First, we find that the probability of banks' participation was positively associated with size, commercial lending, wholesale funding and unused loan commitments, and negatively associated with liquidity. Large banks that had lower share of liquid assets and deposits were more likely to access crisis funding. These banks also supplied more business loans relative to non-participating banks, suggesting that banks participated in the liquidity programs to continue lending. Second, we find that participating banks would borrow more from the programs as they relied more on wholesale funding. Such findings are consistent with the objective of these liquidity programs, which is to assist banks that are viable in the future but face temporary illiquidity. Lastly, using difference-in-difference estimation we find no robust evidence that liquidity programs affected business loans after controlling for different control variables, dummy definitions and model specifications.

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1. Introduction

The crisis of 2007-2009 raised concerns about credit risk and liquidity shortfall in major financial markets. Banks faced increased liquidity risk due to a run by short-term bank creditors and drawdowns of credit lines by borrowers. To protect themselves, banks hoarded liquidity by accumulating liquid assets at the expense of new loan originations. In response to sharp declines in bank lending and funding pressures, the Federal Reserve (Fed) implemented several crisis liquidity programs[1] to improve credit conditions (Figure 1). These liquidity programs were designed to serve two purposes: inject liquidity to the markets and restore credit flows.

The effectiveness of the liquidity programs has still remained a controversial debate in the literature. While several studies show that the programs were successful in easing the stress in interbank and other funding markets (McAndrews, Sarkar and Wang, 2008; Duygan-Bump et al., 2013), others argue that they have led to increased risk taking in banks (Acharya, Drechsler and Schnabl, 2014) without boosting loan growth (Black and Hazelwood, 2013; Duchin and Sosyura, 2014). They also suggest that these lending programs resulted in inefficiencies, as they allowed big players to earn record profit both during and in the aftermath of the crisis (Bloomberg[2], 2011; Akay et al, 2013).

(Insert Figure 1 about here)

Over the period, the Fed expanded its balance sheets from $800 billion at the start of the crisis to about $2.6 trillion by June 2008 through the liquidity programs (Wall Street Journal, 2011). Due to the magnitude of these programs' lending volume, further understanding on their relation with bank performance is highly essential (Figure 1).

In this paper, we study how bank performance is related to the likelihood of participating in seven liquidity programs by U.S. banks. These include Discount Window (DW), Term Auction Facility (TAF), Single-Tranche Open Market Operations (STOMO), Term Security Lending Facility (TSLF), Asset-backed commercial paper Money Market mutual fund Liquidity Facility (AMLF), Primary Dealer Credit Facility

[1] Throughout the paper, the terms 'liquidity programs' and 'lending programs' will be used interchangeably.
[2] According to Bloomberg (2011), banks took advantage of the cheap rates on the Fed loans under the liquidity programs to earn excessive profits throughout the crisis period August 2007 - April 2010. The article can be found on the website: http://www.bloomberg.com/news/2011-11-28/secret-fed-loans-undisclosed-to-congress-gave-banks-13-billion-in-income.html

(PDCF) and Commercial Paper Funding Facility (CPFF)[3]. Using daily lending data under each program from Bloomberg LP, we assess banks' decision to access the programs with respect to their financial performance. Our research seeks to address three questions: 1. How is bank performance related to their participation in the programs? 2. What drives banks' program utilisation? 3. What is the impact of these liquidity programs on banks' post-crisis lending capacity? The answers to these questions offer further insights into the underlying reason as to why banks participated in these programs, that is, whether they were driven by liquidity needs or arbitrage opportunities.

Our paper contributes to the broad literature in three aspects. First, we identify banks' accounting performance measures that relate to their participation in seven liquidity programs. In doing so, we provide evidence on the programs' efficiency in targeting viable banks with temporary liquidity needs. We find that participating banks were generally larger and more engaged in commercial lending relative to non-participating banks. Further, these banks experienced increased reliance on short-term debt prior to the crisis[4] and hence, were severely exposed to the capital markets' disruption. Consistent with Cornett, Li and Tehranian (2013), we also find that program participants suffered greater liquidity constraints due to reduction in liquid assets and deposits, as well as drawn down loan commitments by borrowers.

Second, the paper contributes to the increasing literature on banks' liability structure. Our results show robust evidence that banks' decision on the borrowing amounts was driven by their funding structure. Banks that had less stable funding sources, which were deposits and Tier 1 capital, borrowed higher loan amounts. The findings reinforce the importance of stable funding sources in banks and how they play an essential role in banks' resilience to liquidity shocks. Using a larger set of liquidity programs, we are able to validate that banks accessed the programs due to liquidity problems - not for arbitrage reasons.

[3] Detailed description of these programs is provided in Section A in the Appendix.

[4] Dagher and Kazimov (2015) find that banks had been increasingly reliant on wholesale funds (measured by core deposits to assets) since mid 1980s. However, core deposits ratio started to pick up in 2008, reflecting the change in banks' liability structure during the liquidity shocks.

Third, we provide bank-level evidence by assessing the impact of these crisis programs on participating banks' performance. This study is the first that analyses the programs' effect on the interaction amongst bank lending, liquidity and risk factors, using accounting-based financial ratios. This aspect of our paper explores the effects of lending programs on individual banks and sheds further light on the controversial debate on the programs' effectiveness. Using difference-in-difference approach and Heckman two-stage estimation, we find no significant impact on banks' commercial loans. Our findings are in line with other studies, which show that the liquidity programs had marginal or no role in increasing bank lending (Black and Hazelwood, 2013; Egly and Mollick, 2013; Wu, 2015).

The paper has important implications both in the U.S. and abroad. First, it reinforces the role of central banks as lenders of last resort (Domanski, Moessner and Nelson, 2014). Although it has been eight years since the global economic downturn, there are still lessons to be learned. The ongoing sovereign debt crisis in the Eurozone, namely Greece, has highlighted the vulnerability of short-term credit markets and the importance of government bailout. By identifying liquidity and funding factors, amongst others, that attributed to banks' program participation we further highlight the need for a consistent banking framework to ensure that banks satisfy certain threshold requirements on capital, liquidity and even funding structure. This relates to the current regulatory changes in banking, particularly the implementation of Basel III and liquidity revision in recent years.

Second, the fact that we find liquidity programs had no effect on commercial lending raises concerns about whether the implementation of programs were effective in fulfilling the second objective – that is, to increase credit flows. Thus, analyses on Fed crisis programs are useful for future reference as well as current adoption of central banks' unconventional measures around the world (Carpenter, Demiralp and Eisenschmidt, 2014; Agusman et al., 2014).

The rest of the paper is organised as follows. Section 2 provides an overview of the related literature. Section 3 describes the data and banks' financial ratios that are used in the study. Section 4 details the empirical analysis. Section 5 concludes the paper.

2. Related literature

Ever since the crisis, a growing body of literature has examined the Fed's responses in easing market conditions (see Cecchetti, 2009; Domanski, Moessner and Nelson, 2014 and so on). The most prominent strand of the related studies is concerned about the effectiveness of the liquidity programs. To date, the evidence of their impacts on overall financial markets is yet an unresolved controversy in the literature.

A number of studies find supporting evidence that liquidity programs were effective during the crisis. Early works by McAndrews et al. (2008) and Wu (2011) reach similar conclusion, whereby TAF successfully reduced the Libor-OIS[5] spread both on the announcement day and as a permanent impact. Among these, Duygan-Bump et al. (2013) show that AMLF helped stabilise asset outflows from money market funds and reduced asset-backed commercial paper (ABCP) yields. Using difference-in-difference method, they compare how AMLF eligible commercial paper behaved relative to non-AMLF commercial paper (CP), and examine the spread between ABCP and unsecured CP yields under the AMLF. To study the effectiveness of the programs in increasing bank lending, Carpenter, Demiralp and Eisenschmidt (2014) look at the impact of capital injection on originations of commercial and industrial (C&I) loans. By modeling the loan demand and supply separately, they find that the programs helped increase C&I loans by 2.33-3.5%.

On the contrary, other papers show that the objectives of these programs were not successfully achieved. Unlike McAndrews et al. (2008) and Wu (2010), Taylor and Williams (2009) find no robust impact of TAF on the Libor-OIS spread by using different alternative credit risk measures. Recently, several papers have focused on the impact of government bailout programs on both bank lending and risk-taking behaviour. The impaired credit conditions in various financial markets led central banks to employ unconventional tools to foster commercial lending. However, Egly and Mollick (2013) find that Capital Purchase Program (CPP)'s business objective to boost loan growth and business activity was not fulfilled. The capital infusion was reported to be slightly positive and only had impact in larger banks sample. In addition, program funds were given to

[5] The spread between the Libor rate and the Overnight index swap (OIS) rate represents the health of the banking system, where OIS rate measures the average of the overnight interest rates expected (Taylor and Williams, 2009).

banks with an aim to expand lending during period of increased risks (Black and Hazelwood, 2013). Such results reflect the increase in risk taking by Trouble Asset Relief Program (TARP) banks that was documented after the bailout while lending volume remained unchanged (Duchin and Sosyura, 2014). Similarly, Wu (2015) finds that TARP, DW and TAF had only marginal role in increasing bank syndicated lending. As the Fed crisis programs aimed to support the overall functioning of financial system, further understanding on how they impact bank lending is highly relevant and essential.

Given the controversial debate amongst academics and practitioners, this paper aims to provide insights on the 'ex-ante efficiency' of the programs. While several papers assess the impacts and effectiveness of the programs, little research has been done on the relation between banks' pre-crisis characteristics and program participation. One of the ways to measure the effectiveness of these programs would be to determine whether the funds were targeted to the right bank groups in the first place.

The closest work to our paper is Cornett, Li and Tehranian (2013), whereby they evaluate the pre-crisis health of banks and how it is related to the probability of receiving and repaying TARP capital. In doing so, they look at the quarterly operating performance of TARP CPP recipient and non-recipient banks from 2007Q1 to 2011Q1. The paper concludes that income ratios are more significant in determining the probability of receiving TARP for small banks while liquidity ratios are the main factor for large banks. In a similar spirit, our paper investigates bank-level characteristics that are attributed to the access of the Fed's crisis lending.

Our research differs from their work in two ways. First, we identify the factors that drive bank participation in seven liquidity programs during the crisis, rather than focusing on TARP CPP. As each lending facility aims to resolve issues relating to particular asset types, greater coverage of the other programs would allow us to identify the common performance measures that lead banks to participate in these programs. Further, due to the size of the lending volume under the liquidity programs, analyses on their efficiency are important and should not be overlooked.

Second, our paper bridges the main strands of related literature by assessing the impacts of the programs on bank lending. Our focus is on bank-level evidence and

whether the liquidity programs have changed lending patterns in banks. The findings would extend and validate previous arguments that have been discussed in the literature.

3. Data and Measurement of Variables

3.1. Data

Our sample data covers from 2007Q1 to 2012Q3, which includes 23 quarters in total. We obtain the quarterly Consolidated Financial Statements for Bank Holding Companies (FR Y-9C) from the Federal Reserve Bank of Chicago. As the data consolidates accounting information at the bank holding level, we refer to bank as bank holding company (BHC). Our use of BHC data rather than individual commercial banks is consistent with previous studies. Similar to Ashcraft (2004) who finds that BHCs tend to provide capital assistance to weaker subsidiary banks, Berrospide and Edge (2010) argue that BHCs commonly make decisions at the whole institution-level as opposed to on subsidiary-by-subsidiary basis.

The data for Fed lending under each liquidity program are collected from Bloomberg LP. The data contains daily dollar amount of each participating bank's loans outstanding for the period of January 2007 – April 2010. We begin with the lending data for 407 entities that accessed the programs. Since we restrict our sample to only U.S. banks, all foreign and non-financial entities are excluded from the sample. Following this filter, we remain with 295 U.S. firms that participated in the programs whose operation was in financial industries (316 firms operated in the U.S.)[6]. Of these 295 firms, we are able to match 161 entities with the BHC data for the sample period. The unmatched difference is due to the absence of their financial data from FR Y-9C. These firms were either credit unions or banks whose total assets were below the reporting threshold of $500 million and hence, were not required to file on a consolidated basis report FR Y-9C[7]. This represents approximately 46% of the total Fed lending volume.

We combine the lending data with banks' financial performance. This panel dataset is constructed as follows. We gather financial statement data for all U.S. banks that were

[6] All foreign banks were excluded except Barclay PLC, which is based in London, England. This is because the bank's U.S. branch was based in New York and participated in the programs.

[7] After March 31 2006, the reporting threshold all U.S. domestic bank holding companies are required to report financial data on a consolidated basis if their total assets are in excess of $500 million.

active during the sample period. To match participating banks with their corresponding BHCs, we refer to financial reports and FDIC database[8], which documents the organisational hierarchy for each bank.

Since the daily observations under these lending programs do not vary significantly and are mostly zero, we use the quarterly maximum borrowing amounts by each bank under each program as the proxy for banks' participation in our empirical models. We report the summary statistics on these maximum borrowings for the lending period in Table 2. As shown by the statistics, the total maximum borrowing across all programs is approximately $2.4 trillion, whereby TAF program had been mostly used by participating banks. This reinforces the importance of these lending programs to the financial system. We also construct banks' participation proxy in relative terms by scaling the maximum amounts by total lending volume (that is, $2.4 trillion). The scaling of the maximum borrowings gives us a better sense of each bank's participation relative to total bailout funding.

(Insert Table 2 about here)

3.2. Bank performance and Control variables

Bank performance measures - We focus on banks' liquidity, risk and profitability measures since these are possible variables that drive their participation in the programs. Following the Camels framework, we use a set of 11 financial ratios as measures of bank performance characteristics. *Tier 1 capital ratio* reflects the banks' capital adequacy as well as their financial condition (Estrella, Park and Peristiani, 2000; Craioveanu and Mercado-Mendez, 2014). *Loss allowance* is an indicator of the banks' asset quality. The variable *Non-interest expense to assets*, which is calculated as non-interest expense to total assets, controls for the efficiency of the banks' operation. Here, the lower the efficiency ratio of a bank, the more efficient it is in managing non-interest expenses. *Return on Assets (ROA)* captures the overall performance of banks for a given period. As argued by Cornett, Li and Tehranian (2013) pre-crisis ROA is an accurate measure of the banks' health since it represents bank performance conditions as of the latest accounting period prior to distressed times. *Liquid assets* measures the liquidity position of the banks. *Deposits to Assets* and *Commercial papers* measure the banks' funding structure, which captures the fraction of the assets that are financed with deposit funding and

[8] The database can be accessed on the website: https://www2.fdic.gov/idasp/index.asp

commercial paper issues, respectively. *Real Estate loans* and *C&I loans* capture the banks' loan composition as the proportion of real-estate loans and business loans to total assets, respectively. For banks' sensitivity to market shocks, we include *Repricing ratio* to control for banks' exposure to repricing gap. *Repricing ratio* is defined as the ratio of repriced liabilities to repriced assets in a one-year horizon. The higher the ratio, the more interest rate risk that was faced by banks. *Undrawn commitments* measures banks' existing credit lines that were held off-balance sheet relative to total assets.

Bank level controls – Following extant studies, we include a list of control variables to account for other bank and macro-economic factors. We control for bank size by including natural logarithm of total assets *(Ln(Assets))*. *Merger* is a binary variable that is equal to one in the quarter of the acquisition for the acquiring BHC. This is to account for possible effect of bank mergers on the likelihood of program participation. We obtain merger information from the Federal Reserve of Chicago, and refer to the surviving BHC as the acquirer. In addition, we include *Volatility*, *Bank beta* and *Rating* to control for banks' stock price performance, systematic risk and credit risk, respectively. *Volatility* is defined as the volatility of daily stock returns computed over a one-year horizon. *Bank beta* measures the sensitivity of banks' stock returns relative to the return on the S&P500 index. It is estimated from daily returns over a one-year horizon, under the one-factor Capital Asset Market Pricing Model (CAPM). *Rating* captures the banks' creditworthiness, and is assigned a value of one if the banks were given an investment grade for the current quarter and zero otherwise.

Macro-economic controls – VIX is the closing value of the Chicago Board Options Exchange Market Volatility Index. It measures the implied volatility of S&P 500 index options, and is well known as a global proxy for market risk aversion. *Market return* is the equally weighted stock return index from Center for Research in Security Prices (CRSP). *GDP* is the Gross Domestic Product of the U.S., which captures the real side economy of a nation. We also use yield on the 3-month Treasury securities (*Treasury yield*) to control for the effects of interest rate on loan supply and demand. The choice of using the maturity of 3-month is consistent with our use of quarterly data. All control variables are recorded at the end of the quarter. Section B of the Appendix provides the definitions of the bank-level financial ratios and control factors used in the analysis.

Table 3 presents the descriptive statistics of the financial and control variables. In Panel A, we report the statistics for all banks, non-participating banks and participating banks as of 2007Q3, just before the crisis hit. Panel B compares similar statistics for participating banks relative to non-participating banks for three separate subsample periods: 2007Q1-2007Q3 (pre-crisis), 2007Q4-2009Q4 (during crisis) and 2010Q1-2012Q3 (post crisis). This aims to provide a preliminary overview of the trend in participating banks' performance throughout phases of the crisis.

(Insert Table 3 here)

At the end of the third quarter in 2007, participating banks had lower Tier 1 ratio with 10.48%, relative to non-participating banks. However, the ratio is still high and above the regulatory Basel requirement, which suggests that on average, participating banks were well capitalised and had no issues with credit risk. It is also evident that participating banks had lower fractions of liquid assets (*Liquid assets*, mean=11.75%) and deposits to total assets (*Deposits to assets*, mean=72.65%), but generated more business loans (*C&I loans*, mean=13.01%). Not surprisingly, banks that accessed the programs were typically large (measured by *Ln(Assets)*), and were reliant on short-term debt (measured by *Commercial papers*). On average, as these banks were large, they tended to hold more unused credit lines off their balance sheets (*Undrawn commitments*). This reflects the work of Boot, Greenbaum, and Thakor (1993) and Billet, Flannery, and Garfinkel (1995) where they find that loan commitments are positive signals by strong banks.

In Panel B, we separate the sample into three sub-periods, which describe three phases of the crisis. It is interesting to observe a similar diminishing pattern of the variable *Undrawn commitments* for both bank groups over the three periods. This supports the view that borrowers relied more on these credit lines as a financing source in unstable times due to the negative shock on their funding (Berrospide and Meisenzahl, 2013). For both bank groups, the mean ratio of C&I loans to total assets fell consistently as the market entered the recession, and even more so after the crisis subsided. This further motivates our study to look at the role of liquidity programs in boosting lending activities by banks. Similar to other studies, both non-participants and participants

increased their funding from deposits, held more liquid assets and had higher *Tier 1 ratio* since the peak of the crisis.

4. Empirical Analysis

4.1. Probability of bank participation in the liquidity programs

We use probit models to evaluate bank factors that determine the likelihood of using liquidity programs. The model is specified as:

$$Prob(P_i = 1) = \Phi\left(\alpha_0 + \alpha_1 X_{i,pre} + \alpha_2 Z_{i,pre}\right) \quad (1)$$

and

$$P_i = \begin{cases} 1 & if\ bank_i\ participated\ in\ any\ one\ of\ the\ programs \\ 0 & if\ bank_i\ did\ not\ participate\ in\ any\ program \end{cases} \quad (2)$$

where $Prob\ (P_i = 1)$ = the probability of bank i using at least one program; $X_{i,pre}$ = vector of 11 bank performance variables; and $Z_{i,pre}$ = vector of bank and market controls over the period 2007Q3-2008Q3. The variables are discussed in Section 3.

As banks entered the programs at different time period, we choose a common time frame as the start of their participation. Figure 1 supports our choice of 2008Q3 as the starting point since the lending volume for most programs started to increase from this quarter. The financial ratios used are between 2007Q3 and 2008Q3. This is to capture banks' performance for the period just before the crisis began, and other dynamic changes in banks' pre-crisis performance within one year prior to 2008Q3.

We report the results for bank participation across all programs in Table 4. The probit model in column (1) excludes the macro-economic factors in the estimation, while column (2) controls for all factors, including *VIX*, *Market returns*, *GDP* and *Treasury yield*. Due to the high correlation amongst these variables, we include one control factor at a time in our estimation model and the results are quantitatively the same.[9] As the macro-economic controls are the same for all banks for a given quarter, we exclude quarter fixed effect in column (2).

(Insert Table 4 about here)

[9] For space reason, we only report the results when VIX is included in the estimation. The results with the inclusion of other controls are very similar.

The probit models' estimates imply the following findings. First, participating banks held fewer liquid assets[10] and had lower deposit financing compared to non-participating banks. From column (1), a decrease of 1% in the liquidity ratio and deposits would lead to an average increase in z score by 0.015 and 0.016, respectively. This implies that banks with greater liquidity constraints were more likely to access the crisis programs.

Second, banks that relied more on wholesale funding (higher ratio of *Commercial Paper*s) tended to participate in the programs. Following Lehman Brothers failure, these banks were more exposed to the stressed short-term debt markets, and thus were more likely to obtain program funds for financing (coefficient= 0.2, significant at 5%).

Third, there is strong evidence that banks' decision to access the programs was dependent on their size. At the 1% level, we observe that bank size (measured by *Ln(Assets)*) was positively associated with higher probability of program participation. There are two explanations that support this finding. During the crisis, government bailout programs tended to focus on large financial institutions, as their collapses would dampen the financial system further. Another reason is because the Lehman's bankruptcy entailed a run by short-term bank creditors and the drawdowns of unused credit lines by borrowers, which exposed larger banks to liquidity risk (Ivashina and Scharfstein, 2010). Large banks were also encouraged by the Fed to participate with intent to provide credits to consumers and other banks.

Lastly, banks with more *C&I loans* had higher probability of borrowing Fed program funds (coefficient= 0.034, significant at 5%). From column (2), a 1% increase in C&I loans was associated with an increase of 0.034 in z score, after controlling for other market variables. This suggests that banks' decision to access funding was to continue lending, which was consistent with the objective to increase real economy (Carpenter, Demiralp and Eisenschmidt, 2014). We obtain a negative but significant coefficient for *Real estate loans*. One explanation could be that mortgage lenders, whose specialisation is in providing home loans, would not engage in financial transactions and central banks' lending arrangements. There is weak evidence that banks with lower asset quality (*Loss allowance*) were more likely to obtain funding (coefficient=0.146). Further, participating

[10] Duygan-Bump et al. (2013) define Liquid assets alternatively as the sum of repos, Treasury securities, and other U.S. agency notes. We also run the probit models using their measure of Liquid assets and the results remain unchanged.

banks did not suffer from repricing risk and were more efficient in managing their non-interest expenses relative to non-participating banks.

As for the control variables, we find that the estimated coefficients are consistent with our expectation. The coefficients for *Merger*, *Volatility* and *Bank beta* are negative, suggesting that these factors are negatively related to the probability of banks' participation. Bank mergers improved acquired banks' position through the provision of capital or liquidity within the BHC, and hence, decreased the needs for Fed's liquidity support. The negative signs for stock return volatility and bank beta indicate that banks, which had weak stock performance tended to avoid participating in these crisis programs. As argued by Cyree, Griffiths and Winters (2013), the market viewed banks' access to the programs as signs of structural weakness and that negatively affected their stock performance. Consequently, underperformed banks were more reluctant to obtain crisis funding, as this would further deteriorate their share price. We also observe a positive coefficient for *VIX*, which indicates that banks were more likely to participate during times of heightened risk aversion and uncertainty, as characterised by the crisis.

Unlike reported in Cornett, Li and Tehranian (2013), we find that *Tier 1 capital ratio* is not a significant factor in assessing the likelihood of participation in liquidity programs. While TARP focused on the capital side of banks, the seven liquidity programs in our study did not aim to increase banks' capital; rather they were to provide short-term debt financing and liquidity. Our results also show that participating banks were mostly those that had poorer health (lower ROA) relative to non-participating banks before the crisis hit, but the estimate is insignificant.

In column (3), we also include a dummy variable for credit rating in the estimation. For our study period, only 27 banks had credit ratings data and out of those, 18 banks accessed the programs. Due to the small sub-sample size, the resulting estimates are not reliable and therefore, we choose not to include it for further tests. As the estimated coefficient for *Rating* is not statistically significant at the 10% level, we believe that the exclusion of this variable does not cause major issue to our results.

Overall, there is consistent evidence that banks' decision to participate was driven by liquidity and lending needs. As the crisis began, participating banks suffered from liquidity constraint from low holdings of liquid assets and deposits, and were exposed to

liquidity risk due to drawdowns of credit commitments. These banks were large and were major credit suppliers in the markets. Due to their increased reliance on wholesale funding, the stress in the commercial paper markets greatly affected their liability side, leading to greater likelihood of their program participation. The evidence supports the view that liquidity programs were effective in targeting banks with liquidity problems.

4.2. The utilisation of banks' participation in the liquidity programs

As an extension of previous section, we estimate cross-sectional Tobit models to study the determinants of banks' utilisation of program funds. This type of specifications supposes that the unobservable outcome of whether the banks obtain funds under the programs is linearly dependent on a set of pre-crisis bank performance. We refer to the unobservable outcome P_i^* as latent variable. The observable variable P_i is defined to be the latent variable whenever the latent variable is positive, and zero otherwise. In other words, if bank i used at least one program during the period (that is $P_i^* > 0$), the proxy for participation will be equal to our estimated value from the linear model (4), and if bank i did not access the program ($P_i^* \leq 0$) P_i would be zero. Hence, we estimate the following specification for all sample banks:

$$P_i = \begin{cases} P_i^* & if\ P_i^* > 0 \\ 0 & if\ P_i^* \leq 0 \end{cases} \tag{3}$$

where P_i^* = latent variable, which is defined as the maximum aggregate borrowing by bank i scaled by total lending volume across all seven lending programs.

Cyree, Griffiths and Winters (2013) noted that the borrowings under each program could be dependent on bank size. A small bank can have lower borrowing level but the ratio of program loans to total assets can be the same as that of a big bank. The difference in the dollar amounts outstanding between small and large banks are mainly due to their size differential. For robustness, we follow Cyree, Griffiths and Winters (2013) and scale the maximum borrowings by each bank's total assets. We also use total risk-weighted assets and total loans as alternative scaling factors. We estimate the following linear model for program utilisation.

$$P_i^* = \beta_0 + \beta_1 X_{i,pre} + \beta_2 Z_{i,pre} + u_i \tag{4}$$

under the assumption that $u_i \sim N(0, \sigma^2)$.

The vectors of explanatory variables and control factors, $X_{i,pre}$ and $Z_{i,pre}$ are the same

as in previous tests and are as of 2007Q3. The dependent variable is P_i^*, which proxies bank participation (normalised by scaling factors) as at three time stamps in the sample: 2008Q3 (crisis started); 2008Q4[11] (crisis intensified) and 2010Q2 (crisis subsided). The three timestamps represent the evolution of the crisis being at the start, at the peak and at the end, respectively. The aim is to observe the linkage between pre-crisis bank characteristics and program utilisation over time.

We report the results of cross-sectional Tobit models for three time points in Table 5. For all columns, the coefficients on Tier 1 capital ratio and commercial papers are significant. Referring to Column (1) and (2), the coefficient on Tier 1 capital increases in magnitude, from -0.054% to -0.074%, and this suggests that the impact of capital adequacy on program utilisation is higher as the market stress was more severe. As the crisis intensified (column (2)), participating banks with higher pre-crisis undrawn commitments faced higher liquidity risk. For a 1% increase in unused credit lines, the liquidity loans increased by 0.029% on average.

(Insert Table 5 about here)

From the cross-sectional evidence, our conclusion is that pre-crisis Tier 1 capital, commercial paper and deposit funding were the main determinants of program utilisation. In particular, banks that were financed by less core funding sources (Tier 1 capital and deposits) faced difficulty when commercial markets froze in 2008. Consequently, these banks borrowed more from the liquidity programs to support their lending and operation. Further, we observe an increase in the marginal impacts of these funding sources on program utilisation in periods of severe illiquidity. The finding is consistent with the first objective of the programs, whereby banks actively participated for liquidity reasons, and borrowed more aggressively when the markets were in deep recession.

Alternatively, we run panel Tobit models for the full lending period 2007Q3-2010Q2 (12 quarters), whereby vectors $X_{i,pre}$ and $Z_{i,pre}$ are replaced by $X_{i,t}$ and $Z_{i,t}$, respectively. The estimated coefficients of panel Tobit models are presented in Table 6.

(Insert Table 6 about here)

[11] This period was when most of the liquidity programs were introduced.

The models in column (1) and (2) are estimated without and with market control vectors, respectively. On the funding side, banks that had lower deposits and relied heavily on short-term debt borrowed more from the programs. From column (2), an increase of 1% in the pre-crisis commercial paper funding led to an average increase of 0.194% in liquidity loan amounts. On the asset side, participating banks with greater illiquidity due to increased provision of commercial lending and holdings of off-balance sheet unused credit lines also obtained higher loan amounts. For a 1% increase in unused credit ratio, program utilisation increased by 0.011%. Further, weak overall performance and efficiency also determined banks' program utilisation for the full period. So far, the evidence supports the results obtained from the probit models discussed above. By providing panel and cross-sectional evidence, we reach the same conclusion that funding structure is the main reason of banks' vulnerability to liquidity shocks and thus, is a key driver of program utilisation.

For robustness, we use a set of scaling factors for bank participation, including total assets, total risk-weighted assets and total loans. Our results remain unchanged and are quantitatively similar across different measures of participation and control variables. [12]

4.3. The impact of the Fed programs on bank lending

In this section, our objective is to study the impacts of liquidity programs on bank lending, as motivated by the controversy in the literature. As argued by Hamilton (2009), the challenge in studying government interventions is to control for endogeneity of these responses since several interventions might have been used simultaneously. Consequently, we focus on the aggregate usage of seven programs across sample banks as opposed to that of individual programs. Hence, our goal is to study the combined effects of liquidity programs on bank lending rather than attributing the impact to certain programs. We believe that this approach mitigates problems with the simultaneous implementation of different crisis programs, especially when they worked as complements to each other (Pederson and Willardson, 2010; Domanski, Moessner and Nelson, 2014).

[12] In addition, we also estimate the model at different time points throughout the crisis period and the results are the same as those reported.

According to Carpenter, Demiralp and Eisenschmidt (2014), the Fed crisis programs were directly intended to encourage more lending to the real side of the economy. We use C&I loans as the measure of commercial lending. This is because business loans are not generally securitised and hence, they are more reliable measure of bank lending.

Using a panel of quarterly observations from 2007Q1-2012Q3 (23 quarters), we begin with a difference-in-difference analysis. The first difference captures the impact of the programs on banks over time (before and after the crisis), while the second difference captures the cross-sectional variations across banks (non-participant and participant).

$$\Delta Y_{i,t} = \gamma_0 + \gamma_1 After_t + \gamma_2 P_i + \gamma_3 After_t * P_i + \gamma_4 \Delta X_{i,t} + \gamma_5 Z_{i,t} + \delta_i + \lambda_t + \varepsilon_{i,t} \qquad (5)$$

where $\Delta Y_{it,}$ = percentage changes in C&I loans for bank *i*; $After_t$ = an indicator variable that equals one after 2010Q2[13], which is after the closure of all liquidity programs, P_i= an indicator variable that equals one if bank *i* participated in any one of the programs and zero otherwise; $After_t * P_i$= an interaction term that captures the impact of the programs on banks' post-crisis lending; $\Delta X_{i,t}$ = a vector of percentage changes in bank financial ratios; and $Z_{i,t}$ = a vector of bank and market control factors. To control for possible serial correlation of errors over the time, we cluster standard errors at the bank and quarter level. As a robustness check, we include bank (δ_i) and quarter (λ_t) fixed effects to control for heterogeneity between participating and non-participating banks.

The indicator variable $After_t$ captures the time series variation in $\Delta Y_{i,t}$ while the interaction term between $After_t$ and P_i takes into account the cross-sectional variation across banks. If the programs' objective to increase bank lending were fulfilled, we would expect to observe a positive coefficient for the interaction term between the binary variables for post-crisis period ($After_t$) and participation (P_i). It is important to note that, for all specifications, we use percentage changes in the financial ratios to prevent the risk of estimating spurious regressions. As proposed by Zhu (2012), the use of ratios may produce spurious results due to the scaling the dependent and independent variables by the same denominator (that is, total assets).

[13] For robustness check, we also define $After_t$ as post-participation periods, and hence, assign the value of one for periods after 2008Q3 and zero otherwise. The unreported results are very similar.

4.3.1 Baseline regression results

We report the difference-in-difference estimates for commercial lending in Table 7. The specification was estimated using a panel of quarterly data for the period 2007Q1-2012Q3 (23 bank quarters).

(Insert Table 7 about here)

First, we consider the effect of post-crisis on bank lending. The coefficient γ_1 captures the change in C&I loans between before and after the crisis. There is marginal evidence that banks, on average, experienced an improvement in C&I loan growth for the period 2010Q3-2012Q3 (the coefficient is positive but insignificant). The sign is consistent with the trend in C&I loans reported in Figure 1, where commercial lending increased in the post-crisis period.

Turning to the effect of program participation, the coefficient γ_2 captures the difference in banks' lending growth between two bank groups: non-participants and participants. From column (1), participating banks' commercial lending declined by 0.192% relative to non-participating banks, on average. The results contradict with our expectation if the programs were successful. One possible explanation is that this estimate might have been affected by the sharp decline in C&I loans over the sample period, and therefore, resulting in a negative relation. Referring to column (2), a coefficient of 0.09 on the interaction term implies that participating banks experienced an increase of 0.09% in loan growth in post-crisis times. This coefficient exhibits an expected sign but is insignificant.

Our results lend support to the arguments by Black and Hazelwood (2013), Egly and Mollick (2013) and Wu (2015), whereby central banks' support did not increase lending volume. Other explanatory variables are consistent with our expectation. Similar to Cornett et al. (2011), we find that efforts by banks to increase liquidity (holding more liquid assets) reduced the supply of C&I loans to customers. During the crisis, stable funding sources allowed banks to have sufficient fund for their loans and hence, to continue lending (Jung and Kim, 2015). That is why we observe a positive relationship between C&I loans and both *Tier 1 capital ratio* and *Deposits to assets*.

We also follow Cornett et al. (2011) and include *Credit supply*, which takes into account the unused commitments that can be drawn down by the customers and become new loans. This is another measure of a bank's ability to provide credit to its customers given its asset base. The results remain quantitatively the same.

4.3.2 Regression results with alternative participation measure

The degree of participation varies among the sample banks and hence, can have different impact on these banks' performance. It is possible that the liquidity programs had no impact on lending, if the crisis loans were only marginal amounts. After taking into account the transaction costs, for example, interest expenses and transaction fees, the benefits to bank lending were marginal. To examine this, we stratify the sample of participating banks according to their utilisation's thresholds. More specifically, we rank their average program utilisation based on a scale from one to five, where one means lowest participation (20th percentile) and five means highest participation (80th percentile). We then replace the dummy P_i by $High\ P_i$[14] as an explanatory variable to account for the top 20th percentile of participation. Our results for this specification are reported in column (3) and (4) in Table 7.

For the highest participation, we still find no evidence that liquidity programs increased bank lending. The interaction term between participation and post-crisis period becomes larger (but is still insignificant) as we switch from column (2) to column (4), being 0.009 and 0.088, respectively. This suggests that banks with higher program utilisation experienced greater increase in their post-crisis lending growth. However, such evidence is not statistically significant. The rest of the results are very similar to the ones discussed above.

Overall, we find no robust impact of the liquidity programs on banks' commercial loans. This conclusion is reached after considering different participation dummies, participation measures and the inclusion of control factors. We also capture the dynamic interactions between capital, liquidity and funding variables in our model.

[14] $High\ P_i$ is equals to one if bank i's utilisation was in the top 20th percentile, and zero otherwise.

5. Conclusion

In this paper, we examine the relation between bank performance and their participation in crisis liquidity programs. This study is important because analyses on non-TARP liquidity programs have been overlooked; yet the total lending volume reached approximately $2.4 trillion during the crisis.

Our main findings are as follows. First, we find that the probability of participation is positively related to commercial lending, bank size, undrawn credit lines and wholesale funding and is negatively related to liquidity. These results confirm that the main reasons for banks to access lending programs were due to liquidity constraints, hence, supporting the efficiency of these programs. Second, banks with low stable funding suffered more funding illiquidity and thereby increased their borrowings accordingly. Third, the evidence of this paper confirms the argument by Egly and Mollick (2013), Duchin and Sosyura (2014), and Wu (2015). After controlling for asset size, bank specific variables and other macroeconomic controls, we find no robust impact on bank lending. While we support the 'ex ante efficiency' of the liquidity programs in targeting the right bank groups – those that suffered from temporary illiquidity, we are unable to find evidence for the effects on bank lending.

The paper provides important implications for current changes in regulatory policies on the banking system. Our results support the findings of Jung and Kim (2015), whereby funding structure plays an essential role in reducing banks' exposure to market shocks. Future research could extend the current work by looking at how the use of central banks' lending programs has impacted banks internationally. During the crisis, many foreign banks that were based in the U.S. had access to the Fed crisis programs. Thus it is interesting to evaluate the performance of these banks relative to other domestic banks in their countries, which did not have access to the programs. As we restrict our sample to U.S bank holding companies, analyses on cross-country impacts fall outside the scope of this research. Moreover, a study could be carried out using micro datasets on these programs to examine how banks used the Fed loans and whether there has been a significant shift in asset allocation of banks' investment portfolio as a result of that.

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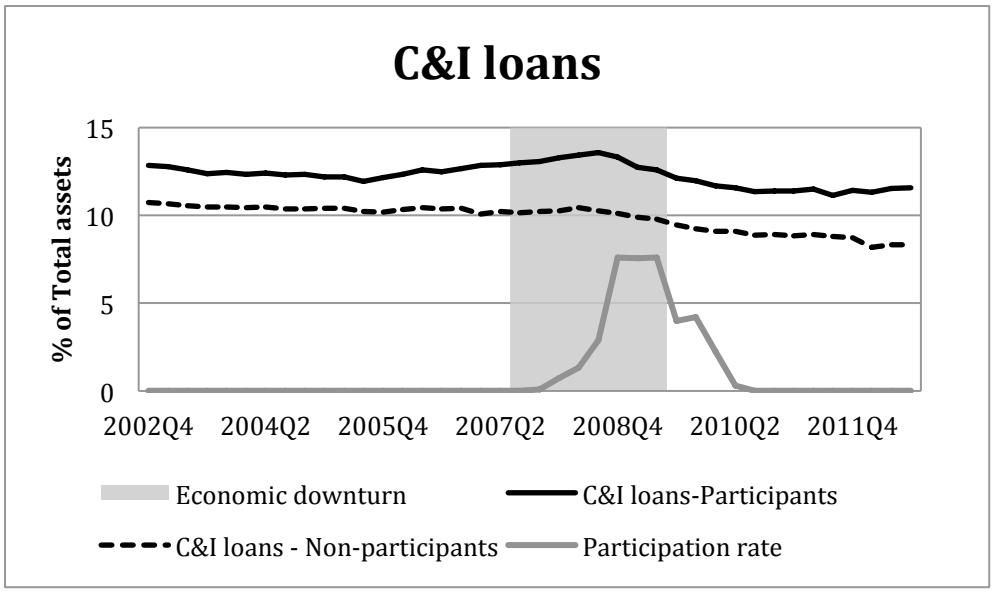
Figure 1: Commercial and Industrial (C&I) loans over the period 2002Q3-2012Q3.



Notes: Both C&I loans and participation rate are expressed as a percent of total assets at time t. The variable Participation rate is calculated by obtaining the maximum total program usage across all participating banks for each quarter. We then scale this measure by banks' total assets. Participating banks are those that accessed at least one lending program during the crisis period. Loan ratios are winsorised at the 1st and 99th percentile.

Table 2: Summary statistics of the Federal Reserve lending programs

Panel A: *n* =406 banks

Variable (in $million)	Sum of maximum amounts	Mean	Min	Min	N
DW	218,191	537	0	37,000	278
TAF	763,176	1,880	0	78,000	406
PDCF	283,620	699	0	61,292	18
TSLF	349,747	861	0	38,510	18
STOMO	260,423	641	0	45,000	19
AMLF	154,139	380	0	77,802	7
CPFF	387,233	954	0	37,291	80
Total Volume	2,416,528				

Panel B: *n* =161 banks

Variable (in $million)	Sum of maximum amounts	Mean	Min	Max	N
DW	63,850	397	0	29,000	126
TAF	393,448	2,444	0	78,000	151
PDCF	169,429	1,052	0	61,292	6
TSLF	161,503	1,003	0	36,000	7
STOMO	80,513	500	0	34,450	7
AMLF	153,900	956	0	77,802	6
CPFF	83,600	519	0	25,127	14
Total Volume	1,106,243				

Notes: The data are collected from Bloomberg LP. We report the descriptive statistics of maximum borrowing amounts outstanding for each lending facility from each bank. *Total Volume* is calculated as the total of the maximum amounts' sums across seven programs. Amounts are in million dollars.

Table 3: Summary statistics of financial performance measures

Panel A: Descriptive statistics of financial ratios as of 2007Q3						
	All banks (n=975)				Non-participants (n=835)	Participants (n=140)
Financial ratios (%)	Mean	Std. dev.	Min	Max	Mean	Mean
Capital adequacy						
Tier 1 capital ratio	11.86	3.81	0.39	36.06	12.10	10.48 [a]
Asset quality						
Loss allowances	1.21	0.44	0.44	4.76	1.21	1.22 [a]
Management efficiency						
Non-interest expense to assets	2.25	0.80	0.42	6.53	2.24	2.30
Earnings						
Return on assets	0.48	0.07	-2.40	2.24	0.48	0.50
Liquidity						
Liquid assets	14.84	9.41	2.78	55.11	15.35	11.75 [a]
Funding composition						
Deposits to assets	76.69	10.32	30.55	91.80	77.36	72.65 [a]
Commercial papers	0.05	0.28	0.00	1.92	0.03	0.16 [a]
Loan composition						
Real estate loans	53.30	14.70	4.68	80.01	53.82	50.26 [a]
C&I loans	10.56	6.46	0.09	34.09	10.15	13.01 [a]
Sensitivity						
Repricing ratio	94.44	57.44	0.00	376.79	96.91	79.68
Undrawn commitments	7.97	4.18	0.00	19.04	7.75	9.29
Bank-level controls						
Ln(Assets) - in $thousands	14.12	1.26	11.93	18.90	13.93	15.30 [a]
Volatility	0.36	0.14	0.17	1.21	0.36	0.36
Bank beta	0.38	0.31	-0.26	1.74	0.33	0.52
Program participation (%)						
Fundings/ total assets					-	0.03

Notes: To avoid issues with outliers, banks financial ratios that are reported in Panels A and B have been winsorised at the 1st and 99th percentiles. Financial performance measures that are used in the analysis have also been winsorised at these specified percentiles. All financial ratios are expressed in percent, except *Ln(Assets)* is in absolute terms and beta. Panel A reports statistics of financial ratios for all sample banks (n=975), non-facility banks (n=835) and facility banks (n=140) as of 2007Q3.

We perform two-sample t-tests, where [a] denotes significantly different than non-participants at the 1% level.

Panel B: Statistics of financial ratios for subsample periods

	Non-participants			Participants		
	Pre-crisis	In-crisis	Post-crisis	Pre-crisis	In-crisis	Post-crisis
Financial ratios (%)	Mean	Mean	Mean	Mean	Mean	Mean
Capital adequacy						
Tier 1 capital ratio	12.17	11.62	13.60	10.55	10.75	12.86
Asset quality						
Loss allowances	1.21	1.59	2.03	1.21	1.82	2.38
Management efficiency						
Non-interest expense to assets	1.51	2.09	1.89	1.56	2.16	1.96
Earnings						
Return on assets	0.47	0.27	0.17	0.51	0.25	0.17
Liquidity						
Liquid assets	16.06	14.22	18.24	12.24	11.78	15.13
Funding composition						
Deposits to assets	77.90	77.69	80.41	73.37	71.52	75.77
Commercial papers	0.04	0.03	0.01	0.16	0.12	0.09
Loan composition						
Real estate loans	53.35	54.08	49.35	50.29	49.30	44.68
C&I loans	10.15	9.95	8.71	12.92	12.89	11.45
Sensitivity						
Repricing ratio	97.31	103.76	97.87	80.58	80.58	74.40
Undrawn commitments	7.77	5.74	3.99	9.41	6.72	4.48
Bank-level controls						
Ln(Assets) - in $thousands	13.92	13.94	13.95	15.27	15.34	15.37
Volatility	0.00	-0.01	0.00	0.00	-0.01	-0.01
Bank beta	0.28	0.71	0.48	0.26	0.73	0.45
Program participation (%)						
Fundings/ total assets	-	-	-	0.01	4.00	0.24

Panel B reports the statistics of financial ratios for non-participating and participating banks for three different sub-periods: 2007Q1-2007Q3, 2007Q4-2009Q4 and 2010Q1-2012Q3. Banks' financial ratios that are reported in both Panels have been winsorised at the 1st and 99th percentiles. All financial ratios are in percent, except *Ln(Assets)* is in absolute terms and beta. Detailed definitions of these variables are provided in Section 2 of the Appendix.

Table 4: Results for Probit Model – using pre-crisis measures between 2007Q3-2008Q3

Dependent variable is the binary indicator variable that equals one if bank i borrows at least one of the Fed programs and zero otherwise. Banks' financial performance measures are from 2007Q3-2008Q3, and are expressed in percent. All accounting performance ratios have been winsorised at the 1st and 99th percentiles. Standard errors are clustered at bank and quarter level. The sample is reduced due to the inclusion of bank-level controls (for example, stock returns).
***/**/* denote significance at the 1%, 5% and 10% level, respectively.

Dependent variable: P_i =1	[1]		[2		[3]	
Parameter	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
Intercept	-4.055***	1.109	-4.689***	1.161	2.060	5.988
Capital adequacy						
Tier 1 capital ratio	-0.023	0.032	-0.026	0.030	-0.210***	0.068
Asset quality						
Loss allowances	0.126	0.114	0.146	0.107	-1.881***	0.536
Management efficiency						
Non-interest expense to assets	-0.188**	0.074	-0.094**	0.040	-0.169	0.247
Earnings						
Return on assets	-0.029	0.105	0.049	0.082	-0.088	0.407
Liquidity						
Liquid assets	-0.015**	0.006	-0.015**	0.006	-0.165***	0.056
Funding composition						
Deposits to assets	-0.016**	0.006	-0.015**	0.006	0.030	0.061
Commercial paper	0.200**	0.095	0.185**	0.091	3.137***	1.111
Loan composition						
Real estate loans	-0.012**	0.005	-0.011**	0.005	-0.054	0.047
C&I loans	0.034***	0.007	0.034***	0.007	-0.251*	0.129
Sensitivity						
Repricing ratio	-0.003**	0.002	-0.003*	0.001	-0.009	0.008
Undrawn commitments	0.060***	0.011	0.061***	0.011	0.364**	0.181
Bank-level controls						
Ln(Assets)	0.356***	0.047	0.360***	0.047	0.201	0.273
Merger	-0.203	0.213	-0.171	0.206	3.711***	0.741
Volatility	-0.390	0.243	-0.356	0.243	-	-
Bank beta	-0.083	0.151	-0.095	0.153	-	-
Rating	-		-		1.802	0.890
Macro control variables						
VIX	-		0.007	0.006	0.084	0.031
Quarter fixed effect	Yes		No		No	
R-square	0.252		0.249		0.557	
Max-rescaled R-Square	0.378		0.374		0.803	
No. of Observations Used	1730		1730		122	
Freq. of ordered value =1	412		412		88	

Table 5: Results of cross-sectional Tobit model – using pre-crisis measures as of 2007Q3

Dependent variable is the maximum aggregated program usage scaled by the total volume across all programs. Banks' financial performance measures are as of 2007Q3. Bank-level controls include Ln(Assets), Merger, Volatility and Bank beta. Macro-economic factors are the same for all banks for the given quarter, and therefore, are excluded for econometric reasons. Standard errors are clustered at bank and quarter level. ***/**/* denote significance at the 1%, 5% and 10% level, respectively.

Dependent variable: Aggregate loans/Total lending volume

	(1) 2008:Q3		(2) 2008:Q4		(3) 2010:Q2	
Parameter	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
Intercept	-0.986	1.314	-0.388	1.359	0.270	0.837
Capital adequacy						
Tier 1 capital ratio	-0.054*	0.028	-0.074**	0.032	-0.049**	0.019
Asset quality						
Loss allowances	0.031	0.139	0.018	0.140	0.066	0.085
Management efficiency						
Non-interest expense to assets	-0.027	0.063	-0.024	0.064	-0.035	0.040
Earnings						
Return on assets	0.153	0.143	0.180	0.147	0.133	0.086
Liquidity						
Liquid assets	0.002	0.008	0.001	0.008	0.002	0.005
Funding composition						
Deposits to assets	-0.003	0.006	-0.009	0.006	-0.009**	0.004
Commercial papers	0.314***	0.115	0.366***	0.120	0.269***	0.071
Loan composition						
Real estate loans	-0.011*	0.006	-0.013**	0.006	-0.005	0.004
C&I loans	-0.008	0.009	-0.004	0.009	0.004	0.005
Sensitivity						
Repricing ratio	-0.001	0.002	0.000	0.001	0.000	0.001
Undrawn commitments	0.018	0.014	0.029**	0.014	0.014	0.009
Bank-level controls	Yes		Yes		Yes	
Quarter fixed effect	Yes		Yes		Yes	
Bank fixed effect	Yes		Yes		Yes	

Table 6: Results of panel Tobit model – using pre-crisis measures as of 2007Q3

Dependent variable is the maximum aggregated program usage scaled by the total volume across all programs. Banks' financial performance measures are as of 2007Q3. Bank-level controls include Ln(Assets), Merger, Volatility and Bank beta. Macro-economic factors include VIX, Market returns, GDP and Treasury yield. Standard errors are clustered at bank and quarter level. ***/**/* denote significance at the 1%, 5% and 10% level, respectively.

Dependent variable: Aggregate loans/Total lending volume

	(1) Full sample			(2) Full sample		
Parameter	Estimate	Std. error	Signifi.	Estimate	Std. error	Signif.
Intercept	-2.088	0.203	***	-1.704	0.287	***
Capital adequacy						
Tier 1 capital ratio	0.000	0.003		0.000	0.004	
Asset quality						
Loss allowances	0.044	0.011	***	0.021	0.015	
Management efficiency						
Non-interest expense to assets	-0.004	0.007		-0.031	0.010	***
Earnings						
Return on assets	-0.022	0.013	*	-0.039	0.018	**
Liquidity						
Liquid assets	-0.003	0.001	**	0.000	0.002	
Funding composition						
Deposits to assets	-0.009	0.001	***	-0.009	0.001	***
Commercial papers	0.056	0.027	**	0.194	0.031	***
Loan composition						
Real estate loans	0.001	0.001		-0.002	0.001	
C&I loans	0.009	0.002	***	0.009	0.002	***
Sensitivity						
Repricing ratio	0.000	0.000	**	-0.001	0.000	***
Undrawn commitments	-0.003	0.003		0.011	0.004	***
Bank-level controls	Yes			Yes		
Macro control variables						
VIX	-			0.004	0.002	**
Quarter fixed effect	Yes			Yes		
Bank fixed effect	Yes			Yes		

Table 7: Results of Difference-in-difference estimation using panel of quarterly data from 2007Q1-2012Q3.

Notes: Dependent variable is the quarterly percentage changes of C&I over the period 2007Q1 – 2012Q3. Other controls (banks' characteristics following Camels framework) are computed in a similar manner as the dependent variable. Prefix Δ denotes the quarterly change in the financial ratios of the banks. All financial ratios have been winsorised at the 1st and 99th percentiles. Market controls include VIX, Market return, Treasury yield and Gross Domestic Product (GDP). The number of banks included in this panel data set varies across the quarters due to banks entered and exited. We also lose some banks due to data unavailability. Standard errors are clustered at the bank quarter level, and are reported in parentheses. ***/**/* denote significance at the 1%, 5% and 10% level, respectively.

Dependent variable: Δ C&I loans	[1]	[2]	[3]	[4]
Parameter	Estimate	Estimate	Estimate	Estimate
Intercept	-0.517	-1.428***	-0.538	-1.410***
	[1.369]	[0.519]	[1.373]	[0.519]
After	0.022	0.130	0.022	0.130
	[0.055]	[0.093]	[0.055]	[0.093]
P	-0.192	-0.021		
	[0.416]	[0.026]		
After * P	0.025	0.009		
	[0.048]	[0.035]		
High P			-0.219	-0.040
			[0.423]	[0.056]
After * High P			0.054	0.088
			[0.075]	[0.068]
Δ Tier1 capital ratio	-0.028**	-0.023**	-0.028***	-0.023**
	[0.010]	[0.011]	[0.010]	[0.011]
Δ Liquid assets	-0.116***	-0.114***	-0.116***	-0.114***
	[0.006]	[0.006]	[0.006]	[0.006]
Δ Deposits to assets	0.008*	0.015***	0.008*	0.015**
	[0.004]	[0.006]	[0.004]	[0.006]
Δ Undrawn commitments	0.016**	0.017*	0.016**	0.017*
	[0.007]	[0.009]	[0.007]	[0.009]
Bank-level controls	Yes	Yes	No	Yes
Macro control variables	No	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
R-Square	0.188	0.1291	0.1234	0.1291
No. of Observations Used	22311	19343	19343	19343

APPENDIX

A. The Implementation of the Federal Reserve liquidity facilities

Referring to Willardson and Pederson (2010), we categorise the liquidity programs implemented by the Federal reserve into three main groups: Programs supporting banks, programs supporting primary dealers and programs supporting commercial paper/ money markets.

I. Programs supporting banks

Discount Window (DW) has long been perceived as the central bank's mechanism in the role of lender of last resort. Alongside with open market operations, lending under DW is a way in which the Fed injects liquidity into financial markets.

In response to the stigma that was attached with DW, the Fed created a new funding program, *Term Auction Facility (TAF)* (December 2007 – March 2010). TAF provided short-term funds for depository institutions, whereby these institutions bided in a single-price auction for collateralized term funds. The term funding was initially for 28 days and later 84 days with higher auctioned amounts.

II. Programs supporting primary dealers

The strained repurchase agreements (repo) market made primary dealers become more concerned with the risk of the counterparties and their pledged securities. As a result, the Fed created *Primary Dealer Credit Facility (PDCF)* (March 2008 – February 2010). PDCF was an overnight loan facility for primary dealers to reduce the pressure in the overnight repo market. The Fed provided overnight cash loans, in the forms of repos, at the primary cash rate to eligible primary dealers in exchange for the collateralized assets.

An alternative source of liquidity for primary dealers is *Term Securities Lending Facility (TSLF)* (March 2008 – February 2010). This is a weekly 28-day loan facility that promotes liquidity in Treasury and other collateral markets. It offered Treasury securities held by the System Open Market Account (SOMA) for loan over a one-month term against other program-eligible general collateral. The Fed loaned liquid U.S. treasury securities while primary dealers paid a fee to the Fed and bought government securities directly with intent to resell to others.

In addition to the other two programs, *Single-Tranche Open Market Operations* (STOMO) (March 2008 – February 2010) was created. The program worked as temporary open market operations to provide term funding to primary dealers. The Federal Reserve

Bank of New York conducted single-tranche term repos with primary dealers in an auction process. In exchange, participated primary dealers could deliver any assets that are acceptable in regular open market operations (e.g. treasuries and agency debt).

III. Programs supporting commercial paper/ money markets

To reduce the strains in money market mutual funds, the Fed created Asset-backed commercial paper Money Market Mutual fund Liquidity Facility (AMLF) (September 2008-February 2010). AMLF provided loans to banks at a primary credit rate to purchase high quality asset-backed commercial paper (ABCP) from the money market mutual funds (MMMFs). Eligible banks used the Fed loans to buy ABCP from the MMMFs at amortised costs. The positive spread between paying the interest on Fed loan at the cash rate and purchasing the ABCP at amortised cost was seen as an incentive for banks to participate (Duygan-Bump et al., 2013).

In October 2008 the Fed implemented the Commercial Paper Funding Facility (CPFF) (October 2008-February 2010) to ease the pressure in the CP market. Under the facility, the Fed created and funded a limited liability company, a special-purpose vehicle (SPV), with the Federal Reserve of New York as the only beneficiary of the new company. The Fed provided financing to the SPV, whereby the vehicle purchased three-month unsecured commercial paper and asset-backed commercial papers from eligible U.S. issuers. The price of commercial papers was discounted at the spread of three-month index swap: 300 basis points for ABCPs and 100 basis points for unsecured commercial papers plus a credit surcharge of 100 basis points[15].

B. Description of bank-level performance ratios and controls.

Category	Variable	Definition
Earnings	*Return on assets (ROA)*	Net income as a percent of Total assets
Capital adequacy	*Tier 1 capital ratio*	Tier 1 capital as a percent of Risk-weighted assets
Management efficiency	*Non-interest expense to assets*	Non-interest expense as a percent of Total assets

[15] Further details on each emergency liquidity program can be found on the Federal Reserve bank's website: http://www.federalreserve.gov/newsevents/reform_transaction.htm

Liquidity	*Liquid assets*	Total liquid assets as a percent of Total assets. *Liquid assets* = sum of non-interest and interest bearing cash balances, non MBS and non ABS (held to maturity and available for sale) securities, Fed funds sold, securities purchased under agreement to resell and trading assets that are in the same categories.
Funding composition	*Deposits to Total assets*	Total deposits as a percent of Total assets
	Commercial papers	Share of commercial papers as a percent of Total assets (borrowed money)
Asset Quality	*Loss Allowances*	Allowances for loan losses as a percent of Total loans
Loan Composition	*Real estate loans to Total assets*	Sum of real estate loans as a percent of Total assets
	C&I loans	Sum of commercial and industrial loans to Total assets
Sensitivity	*Repricing ratio*	Sum of repriced liabilities to total repriced assets in a one-year horizon
	Undrawn commitments	Undrawn commitments to Total assets
Bank controls	*Ln (Assets)*	Natural logarithm of Total assets
	Merger	Binary variable that equals one if there is a merger for the acquiring BHC for a given quarter
	Volatility	Volatility of a bank's stock return over a one-year horizon
	Bank beta	Estimated from a one-factor model CAPM
	Rating	Bianary variable that equals one if a bank is given an investment grade 's rating in a given quarter
Macro controls	*VIX*	Closing value of the Chicago Board Options Exchange Market Volatility Index.
	Market return	Equally weighted index from CRSP.
	GDP	Gross Domestic Product index of the U.S., which captures the real side economy over the sample period.
	Treasury yield	Yield on the 3-month Treasury securities.
		All macro control variables are recorded at the end of the quarter.