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Systemic risk, depositor discipline and institutional interventions in US banking

Francesca D. Lenoci

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Supervisor: Prof. Elena Beccalli

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Abstract

Following a brief introduction in Chapter 1, this thesis investigates the effects of institutional interventions during the recent financial crisis on systemic risk and the consequences of the participation in the Federal Reserve's liquidity programs on depositor discipline. The "boom" period which characterized the years before the financial crisis, has led not only to banks' asset expansions but has been stuck out also by the fact that banks relied much more heavily on short-term debt -in the form of wholesale financing and repurchase agreements-.
Whether this evidence has been validated theoretically and empirically (Adrian and Shin, 2008; Gorton and Metrick, 2012), the second chapter of the thesis investigates the implications of leverage pro-cyclicality in terms of systemic risk: is systemic risk pro-cyclical? In this sense, we analyse whether banks have incentives to be more interconnected and increase their interlinkages during boom periods and decrease them during bursts. The analysis is conducted studying the behaviour of four types of banks depending on their liquidity and capital shortages: banks which participated in the Federal Reserve's Discount Window and Term Auction Facility, banks identified as Systemically Important Financial Institutions, banks under Regulatory Pressure and those which participated in the Treasury's Capital Purchase Program.
The third chapter is devoted to the analysis of the implications -in terms of depositor reaction- of banks' participation in the emergency liquidity facilities. Provided that banks which borrowed from the Discount Window suffered a "stigma" with negative market reactions because perceived as not financially stable, we ask whether depositors react after the access to the program. The analysis is conducted studying the growth rate of guaranteed and non-guaranteed deposits, "now" and time-deposits (among others) one quarter after the borrowing date and when the information was disclosed.

To whom believed in me,

even when she had no reason to do so.

Grazie.

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Chapter 1

Introduction

1.1 Motivation and Contributions

Before the 2007, the financial system was characterized by a "boom" period, banks' balance sheets were expanding and financial intermediaries started to be highly leveraged. Particularly, the increase in indebtedness typically occurred via short-term debt in the form of repurchase agreements and interbank debt (Gorton and Metrick, 2012). Consistently with this evidence and contrary to economic and accounting expectations, Adrian and Shin (2008, 2010) proved that commercial banks operate via leverage targeting, whilst the pure major investment banks in the US actively manage their short-term debt resulting in a pro-cyclical leverage. In other words, the increase in the fair value of assets does not reduce quasi-market leverage ratio because provides incentives for banks to expand their liability-side (this will be discussed further in Chapter 2). The motivation behind this idea lies not only in leverage targeting but also in the reduction of Unit Value at Risk: the increase in the market value of assets allows banks to expand even further their balance sheet via the cheapest source of funding because banks appear to be well capitalised per unit of assets. Hereafter, a lot of empirical papers reported that banks managed their short-term debt especially via repos, interbank debt and wholesale funding in general (Huang and Ratnovski, 2009; Gorton and Metrick, 2012). However, even if wholesale funding provides the benefit of being cheap and immediately accessible in the short-run, the net effect could be called off once we consider implications in terms of systemic risk and depositor discipline.

As long as the increase in the value of assets makes banks larger and more interconnected and banks do not completely internalise the costs of their fragilities, it is worthwhile studying implications of leverage pro-cyclicality on systemic risk. Recognising that the most important sources of funding available to the banking sector (in the short-term) are wholesale and retail deposits of household savers, in Chapter 2 we investigate what happens on systemic risk when banks increase the first component (following the increase in asset values). The hypothesis behind is that retail deposits grow in line with the aggregate wealth of the household sector. In a boom, when credit is growing very rapidly, the growth of bank balance sheets outstrips the growth in the pool of retail deposits. As a consequence, the growth of bank lending results in greater lending and borrowing among the intermediaries themselves (Shin, 2016). Thus, we ask which are the implications in terms of systemic risk (as a negative externality) deriving from the larger dimension, and how the effect is mediated by leverage pro-cyclicality. In the second chapter, we investigate whether systemic risk is pro-cyclical, defined according to Brownlees and Engle (2012) as SRISK (that is, the capital shortfall that a bank would suffer when market returns reduce by 40% in six months). Using a sample of 1,635 US Bank Holding Companies over the period 2006-2016, we show that leverage pro-cyclicality translates into systemic risk: banks become more interconnected during booms and decrease their degree of interconnection during bursts. Using structural equations estimated via Three-Stages Least Squares, in order to tackle the interplay between systemic risk and leverage, we show that the extent of systemic risk pro-cyclicality differs among four groups of banks identified in terms of liquidity and capital shortages. We define as bank with liquidity shortages those having participated in the Federal Reserve's Discount Window and Term Auction Facility. We focus on such banks to empirically investigate the strongest objection linked to the Federal Reserve's programs used to address liquidity shortage: the fear of moral hazard, as access to a liquidity facility may lead banks to opt for bolder policies with less liquidity self-protection (e.g. lower reserves) and, in the event of a liquidity crisis, to choose to incur debt from the Federal Reserve to avoid default on private debts and preserve creditworthiness. Secondly, we concentrate our analysis on banks defined by the Basel Committee on Banking Supervision and FSB as Systemically Important Financial Institutions (SIFIs). SIFIs are especially important because defined as "systemic institutions" and the aim is to verify if extra-capital requirements and the extra-monitoring they are subject to (Supervisory Capital Assessment Program), mitigate the incentives in building up interconnected debt during booms. Lastly, we analyse banks with capital shortages defined as those banks with core capital below 8% (banks under regulatory pressure) and banks which have participated in the Treasury Capital Purchase Program. We devote special attention to these banks because of the implicit moral hazard which might result in more risk taking when their shareholders have less "residual claims". Results show that, leverage is pro-cyclical for banks which have participated in the Term Auction Facility while it is counter-cyclical for banks which have participated in the Discount Window. However, for both type of borrowers, systemic risk increases following the increase in assets with respect to the baseline group, while for auction-based borrowers the increase in leverage leads to a mild increase in systemic risk with respect to the control group. Discount Window borrowers show opposite results: the sensitivity of the increase in systemic risk following the increase in leverage is larger than in the control group, coherently with evidence of "stigma" suffered on the market for these borrowers. Structural equations show that leverage is counter-cyclical for banks under regulatory pressure and banks participating in the Treasury's CPP program, but evidence on systemic risk pro-cyclicality for these sub-samples of banks show contrasting results. CPP banks show a lower degree of systemic risk pro-cyclicality with respect to the control group, while regulatory constrained banks evidence a larger increase in systemic risk following the increase in total assets. Finally, differences come to light for SIFIs: they confirm leverage pro-cyclicality in the structural equation, however when we consider endogeneity of leverage, results do not show systemic risk pro-cyclicality for this group of banks.

When the crisis started, banks which borrowed in the interbank market offering as collateral MBS, began facing difficulties in rolling over their short-term debt; while, banks which were lending against MBS began to suffer losses on loans granted. In few months, this led to a freeze in the wholesale market: the lack of confidence urged banks to raise haircuts and risk-premiums applied on loans. Nevertheless, banks continued to be financed in the short-run via repos signed with the Federal Reserve: the US Central Bank interlaid in the wholesale markets because banks lent not directly to each other, but to the Central Bank and, on the other side, borrowed not directly from each other, but from the Central Bank. In the third quarter of 2007, the Federal Reserve's traditional ways to restore liquidity in the market (repos, DW and credit address to a specific institution) were not enough and the Federal Reserve intervened with emergency programs by revising the Discount Window and introducing the Term Auction Facility (Figure 1.1). Historically, the Discount Window was characterized by subsidised interest rates and addressed to banks which proved to have "exhausted their liquidity": as a result, even if borrowers' name were not disclosed they were somehow found out and banks participating in this program suffered losses in the financial markets because perceived as non-financially stable (Furfine, 2003). Conversely, banks were reluctant to take funds from the Federal Reserve's Discount Window (DW) because in this way they would have been inferred as problematic banks on the market (a phenomenon known as "stigma"). Even if this program has been revised in 2003, by adding a risk-premium over the federal fund rate (FOMC), empirical papers show that "stigma" was not removed (Armantier et al., 2015) and to address this problem and face the liquidity strains the Federal Reserve introduced the Term Auction Facility (TAF). The work described in the third chapter attempts to analyse the presence of depositor discipline following the information disclosure of borrowers' name from the Federal Reserve liquidity facilities. The idea behind this analysis lies in the fact that, if the information disclosure of borrowers' name or the ability of market participants to infer borrowers has led to a negative market reaction, we ask whether the net benefits from liquidity injections might be called off once we consider the likelihood that depositors might react negatively. Whether the presence of market discipline is well recognised in the literature (Armantier et al., 2015), scarce is the evidence concerning depositor reactions following the participation in Lender Of Last Resort facilities. Using quarterly US data (FRY-9C) from 2006

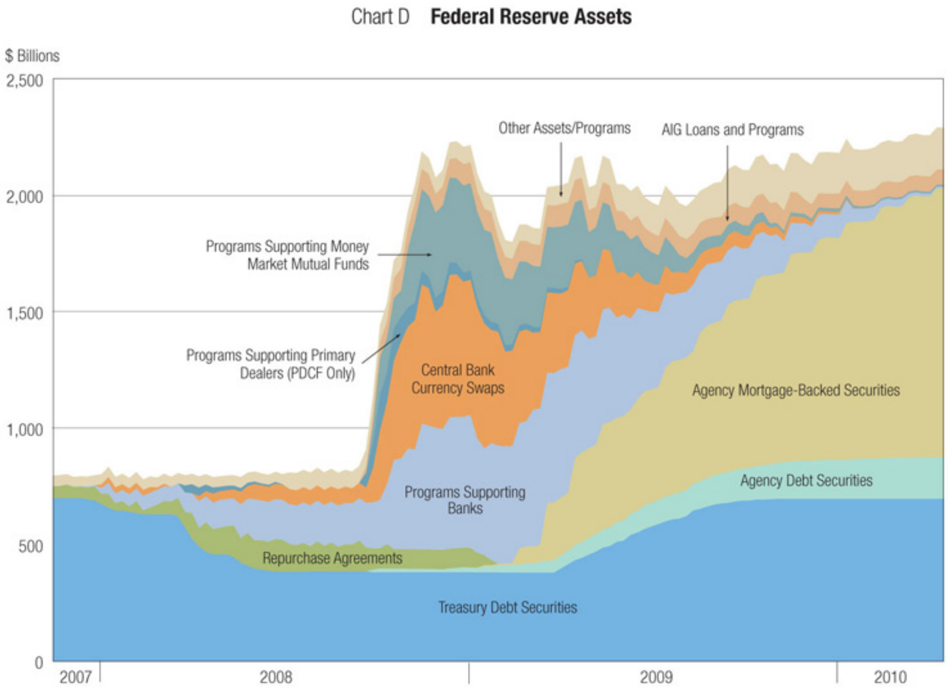


Figure 1.1: Federal Reserve's assets

to 2016, Chapter 3 investigates if, following the contraction in the interbank market, funds from DW and TAF have been used as substitutes of wholesale deposits and whether the perception of financial instability has led to depositor discipline. In particular, we consider as a form of depositor discipline either the withdrawal of deposits (*bank runs*), or the fact that depositors might react by requiring higher risk premium. Moreover, in order to take into account shifting in the composition and preferences among maturities we split the analysis investigating separately all kind of deposits: short-term (demand, liquid, 'now' deposits), time-deposits and the share of domestic deposits. However, we pay special attention on the distinction between "non-guaranteed" and "guaranteed" deposits. Interestingly, results exhibit the presence of depositor reactions with differences among programs and type of deposits: borrowers from Discount Window exhibit a reduction in non-guaranteed deposits whilst borrowers from Term Auction Facility experienced an increase. Lastly, the analysis on deposit market share excludes the presence of herding effects in states different from the state where headquarters are located.

1.2 Policy implications

Our findings are relevant both for regulators and supervisory authorities interested in monitoring banks' behaviour because of the implications in terms of possible macro-prudential policies to mitigate systemic risk and bank runs. In particular, our results touch different aspects of current banking regulation: Chapter 2 relates to the new international regulatory framework -Basel III-, to the extra capital requirements for Too Big To Fail banks, and to the designated procedures in order to evaluate capital adequacy to conduct bank business (known as stress test); whilst Chapter 3 relates mainly to the increase in information disclosure provided by the Dodd-Frank Act and to the debate concerning the optimal level of deposit guarantees. Moreover, we refer to the appropriateness of the liquidity programs provided by the Federal Reserve because, on one side, they could create moral hazard, enabling banks to borrow more as a result of the access to these facilities and, on the other side, they might call off their benefits in case in which depositors of Fed's borrower react negatively. Even the magnitude of extra capital requirements for systemically important banks is relevant: in fact, if current requirements are sufficient to counter the increase in systemic risk, it could be that more stringent requirements might have negative effects.

The results from the second chapter have implications in terms of regulatory capital requirements, state-aid in the form of capital injections, liquidity provisions by the Federal Reserve and mandatory disclosure of information. The analysis shows that banks that get into debt through the Term Auction Facility show leverage pro-cyclicality but have no implications in terms of pro-cyclical systemic risk; while banks which borrow through the Discount Window are those that suffer the most in terms of systemic risk. As demonstrated by Armantier et al. (2015), Discount Window borrowers suffer negative reactions on the market as a result of the participation in this facility and we add to their work pointing out the negative implications in terms of systemic risk. In this way, the liquidity provision from the US Central bank and the disclosure of Discount Window borrowers' name are two opposing forces which go against each other for the financial wealth of the bank. On the contrary, as regards the effects on systemic risk pro-cyclicality, the extra capital requirements for SIFIs or their compliance to the Supervisory Capital Assessment Program demonstrate to achieve regulators' goal. Although TBTF banks confirm pro-cyclical leverage, there are no effects on pro-cyclicality of systemic risk. Finally, for what concerns implications in terms of financial fragility and interconnectedness, our results prove that the regulator's attention should not be directed to banks that are capital constrained (for which we show that an increase in assets value does not involve any increase in leverage and for which leverage do not increase systemic risk more than in the control group) but to well-capitalised banks, having the incentives to borrow and increase systemic risk. The last section of the second chapter shows results concerning interactions between programs. The sample of banks which participated jointly in the Term Auction Facility and in the Capital Purchase Program show virtuous results: they evidence a counter-cyclical leverage and a counter-cyclical systemic risk with respect to the control group when we take into consideration endogeneity of leverage estimated via structural equation. In this way, we show that banks which benefits from institutional interventions both on the equity side and on the (short-term) liability side move towards the stability desired by regulators in terms of leverage and interconnectedness. In terms of banks' incentives to payback Treasury's capital and regulator's policy to foster early repayments, we notice that banks participated by the Treasury which have not paid-back preferred stock in the following year have not suffered neither pro-cyclicality of leverage, nor pro-cyclicality of systemic risk (albeit the leverage component increases systemic risk more than in the control group once we take into account pro-cyclicality of leverage).

Chapter 2

Is systemic risk pro-cyclical?

This chapter investigates the pro-cyclicality of systemic risk, defined according to Brownlees and Engle (2012) as SRISK. Using a sample of US Bank Holding Companies over the period 2006-2016, we show that leverage pro-cyclicality translates into systemic risk: banks become more interconnected during booms and decrease their degree of interconnection during bursts. Moreover, using structural equations to tackle the interplay between systemic risk and leverage, we show that the extent of systemic risk pro-cyclicality differs among four groups of banks identified in terms of liquidity and capital shortage. Banks that had access to the liquidity facilities activated by the Federal Reserve (e.g. Discount Window and Term Auction Facility) show a higher degree of pro-cyclicality of systemic risk; this is motivated by their lower cost of financing that allows them to increase debt at least in the short-run. Banks approaching or below the regulatory capital threshold (e.g. banks under regulatory pressure) and banks that participated in the Capital Purchase Program (CPP) show a lower degree of pro-cyclicality of systemic risk. Finally, banks with the status of TBTF unexpectedly show no difference in the degree of pro-cyclicality of systemic risk with respect to the baseline group.

2.1 Introduction

The recent financial crisis has shown how strong is the linkage between the real and financial sector. A vast amount of literature highlighted how periods of economic booms are forerun by unexpected growth in lending and how the opposite happens during crisis: a phenomenon known as pro-cyclicality of credit (Berger and Udell, 2004; Gambacorta and Mistrulli, 2004; Bikker and Metzemakers, 2005; Bertay et al., 2015). Moreover, under Basel II capital framework, both empirical and theoretical papers show that the source of pro-cyclicality in lending arises (among others) from current capital requirements (Andersen, 2011; Repullo and Suarez, 2013). During recessions, when the value of equity decreases because losses erode bank's capital, banks might either increase capital or reduce risk-weighted assets in order to satisfy more stringent capital requirements. Even if the decision is twofold, difficulties faced by banks in raising capital during crises and debt-overhang hypothesis lead them to reduce their main assets via credit rationing. Thus, as stressed by the BCBS and FSF (2009), in order to mitigate this source of pro-cyclicality, Basel III introduced counter-cyclical capital requirements.

In addition to the pro-cyclicality of credit, recent literature has investigated the interaction between the asset and liability side via the so-called leverage pro-cyclicality (Fostel and Geanakoplos, 2008; Adrian and Shin, 2010b; Huizinga and Laeven, 2012; Baglioni et al., 2013; Damar et al., 2013; Beccalli et al., 2015; Amel- Zadeh et al., 2015; Acharya and Ryan, 2016). Along different time periods and different countries, banks (especially investment banks) have shown not to use a passive management of leverage; instead, they are increasingly shifting towards active management and pro-cyclical behaviours, that means to amplify the asset side via more debt during booms (and contracting it, via deleveraging, during burst). The milestone in this field are the findings from Adrian and Shin (2010, 2013): when assets are evaluated at *fair value* an increase in market price would decrease "quasi-market leverage ratio"[1] and, for those banks which operate through leverage or VaR targeting, this leaves room to build up debt. Their empirical findings show that banks' balance sheets expand by borrowing more during booms and contract during bursts (leverage is pro-cyclical). Furthermore, the recent financial crisis has drawn our attention on another phenomenon: the degree of interconnection among banks and their systemic dimension. Particularly, a bank is considered "systemic" when its distress or failure may threat the financial stability and impairs the functioning of the financial system as a whole with significant adverse effects on the broader economy (Freixas et al., 2015). As long as the increase in the value of assets makes banks larger and more interconnected (i.e. via an increase in the interbank debt) and banks do not completely internalise costs of their fragilities, it is worthwhile studying implications of leverage procyclicality on systemic risk. That is, active management of leverage might create a negative externality and this fragility may propagate among banks decreasing overall stability. During the last decade both micro- and macro-prudential regulation became

[1] Quasi-market leverage ratio is defined as $\frac{A_{fv}}{E_{fv}} = \frac{A_{fv}}{A_{fv}-D_{acc}}$.

highly active on this topic identifying some banks as Systemically Important Financial Institutions (SIFIs), monitoring these banks via stress test (SCAP in the US), considering pro-cyclical capital requirements, limiting banks' activities and increasing the transparency of information (Dodd-Frank Act).

Following the evidence on leverage pro-cyclicality and the attention devoted by regulators to systemic banks, the main contribution of this chapter is to show that the pro-cyclical behaviour of banks does not concern just their leverage but also their degree of interconnectedness with the financial system and their systemic contribution within the financial sector (i.e. pro-cyclicality of systemic risk). Moreover, we differentiate among four groups of banks characterized by either liquidity or capital shortage to investigate the effects on pro-cyclicality of leverage and systemic risk. We focus on such banks to empirically investigate the strongest objection linked to the Federal Reserve's programs used to address liquidity shortage: the fear of moral hazard, as access to a liquidity facility may lead banks to opt for bolder policies with less liquidity self-protection (e.g. lower reserves) and, in the event of a liquidity crisis, to choose to incur debt from the Federal Reserve to avoid default on private debts and preserve creditworthiness. First, we exploit the exogenous variation in the characteristics of banks requiring funds from the Federal Reserve and we find that banks that participate in Lender of Last Resort programs ($LOLR$), like Discount Window and Term Auction facility, are more likely to increase their short-run indebtedness even with other sources of funding (like Federal Reserve's repo and interbank debt): for these banks the degree of leverage pro-cyclicality is even higher than that of banks in our baseline model. The increased reliance on short-term funding (worsening liquidity fragilities) directly translates into a higher systemic contribution in the quarter following the access to these facilities originating systemic risk pro-cyclicality (although with differences among these two programs). Second, banks identified by regulators (Basel Committee on Banking Supervision and Financial Stability Board) as Domestic or Global Systemically Important Banks increase debt in the short-run via repos: this immediately translates into leverage pro-cyclicality. However, our evidence shows unexpected results on their degree of interconnectedness following an increase in the market value of assets: if fixed-effect regression shows pro-cyclicality of systemic risk for SIFIs, structural equation model does not confirm this result once we account for endogeneity of leverage. Third, banks under regulatory pressure, defined as banks with core capital below 8%, not only do not increase their leverage (at least in the short-run) but even decrease it during asset expansion. Moreover, our evidence confirms that the deleveraging process translates into systemic risk: the pressure to be compliant with stricter capital requirements leads these banks to decrease the pro-cyclicality of systemic risk arising from leverage with respect to the control group. Fourth, banks that have taken part in the Treasury's Capital Purchase Program, similarly to banks under capital pressure, reduce leverage in the short-run arising from the increase in asset value (immediately following Treasury's participation in their capital); whilst they show counter-cyclical systemic risk with respect to the control group.

In more detail, our first set of tests replicates the fixed-effects model by Adrian and Shin (2010) and, using quarterly data from a sample of 1,635 US Bank Holding Companies (BHCs) from 2006 to 2016, our baseline model confirms that leverage is pro-cyclical. Furthermore, we consider four sub-samples of banks: those participating into Federal Reserve's liquidity injections facilities - *LOLR* -, those designated as *SIFIs*, those under regulatory pressure - *Reg. Pressure*- and those participating in Treasury's Capital Purchase Program - *CPP banks* -. Our findings reveal that the degree of leverage pro-cyclicality increases for banks that rely on Federal Reserve's liquidity facilities and for SIFIs; for CPP banks leverage is still pro-cyclical but lower than the control group, whereas leverage is counter-cyclical for banks under regulatory pressure. In our second set of tests, we use again fixed-effect regressions to check for pro-cyclicality of systemic risk. Our findings show that systemic risk is pro-cyclical. Moreover, our results reveal that the degree of systemic risk pro-cyclicality increases for banks that rely on Federal Reserve's liquidity facilities and for SIFIs, whilst systemic risk is counter-cyclical for banks under regulatory pressure; for banks participating into the Treasury's CPP program systemic risk is still pro-cyclical but significant lower than that of control group. Our third set of test, given the multidimensional effects of pro-cyclical behaviour, employs structural equation model (Three Stage Least Squares - 3SLS - regressions). The aim is to study how the effects on pro-cyclicality of leverage and pro-cyclicality of systemic risk interact among them. In particular, we cannot neglect the fact that under general economic theory both the increase in assets and the increase in leverage positively affect the increase in systemic risk and running two separate regressions would lead to a mis-specified model. Thus, to tackle endogeneity of leverage, we perform a structural equation model via 3SLS. Controlling for a set of explanatory variables, our structural equation model allows us to examine the effect of an increase in the fair value of assets on the change in systemic risk disentangling the effects of the increase in leverage and assets. Again, SRISK is found to be pro-cyclical: the links among banks (in terms of their interconnectedness) increase during booms and decrease during bursts. Moreover, structural regression leads to an economically and statistically large difference between banks participating in the Federal Reserve's liquidity programs or banks participating into Treasury's CPP program vs. banks that do not. In particular, leverage is pro-cyclical for banks which participated in the Term Auction Facility program while it is counter-cyclical for banks which participated in the Discount Window; however, for both type of borrowers systemic risk increases following the increase in fair value of assets but some differences come to light when we consider the mediated effect of leverage. Structural equations show that leverage is counter-cyclical for banks participating in the Treasury's CPP program and systemic risk decreases following the increase in assets with respect to banks in the control group. Finally, differences come to light among SIFIs and banks under regulatory pressure vs. banks not belonging in these sub-samples: SIFIs confirm leverage pro-cyclicality, however structural equations do not show systemic risk pro-cyclicality for this group of banks; whilst, regulatory constrained banks evidence counter-cyclical leverage but pro-cyclical systemic risk in the structural equation.

Our findings are relevant both for regulators and supervisory authorities interested in monitoring banks' behaviour because of the implications in terms of possible macro and micro-prudential policies to mitigate systemic risk. In particular, our results touch different aspects of current banking regulation: they relate to the new international regulatory framework -Basel III- and to the extra capital requirements for Too Big To Fail banks, to the designated procedures in order to evaluate capital adequacy to conduct bank business (known as stress test), and to the increase in information disclosure provided by the Dodd-Frank Act. Moreover, we refer to the appropriateness of the liquidity programs provided by the Federal Reserve because they could create moral hazard, enabling banks to borrow more as a result of the access to these facilities. Even the magnitude of extra capital requirements for systemically important banks is relevant: in fact, if current requirements are sufficient to counter the increase in systemic risk, it could be that more stringent requirements might have negative effects. Thereafter, the results of our analysis lead to three types of considerations. First, the evidence that the participation in banks' capital by the Treasury (through CPP program) is seen by the market as a positive signal, alleviating additional borrowing by banks. Second, our results show (surprisingly) that the attention of regulators should not be directed to banks that are capital constrained (for which we show that the increase in asset value does not involve any increase in leverage) but to well-capitalised banks, having the incentives to borrow and increase systemic risk. Third, joint participation in DW and TAF has beneficial effects on systemic risk of banks.

The remainder of the chapter is organised as follows. In Section 2, we review the literature. In Section 3, we provide motivations, describe the methodology and the identification strategy. In Section 4 we describe the data. In Section 5, we investigate whether leverage and systemic risk are pro-cyclical and we report results from structural equation model showing whether banks belonging to the sub-samples of SIFIs, as well as banks that rely on Federal Reserve's liquidity or Treasury's capital injections and banks under regulatory pressure exacerbate or alleviate systemic contributions in the US. Section 6 concludes.

2.2 Literature Review

Our study relates to three main streams of literature concerning the pro-cyclicality of leverage, the measurement of systemic risk and the current safeguards to face the financial crisis in terms of regulation, capital requirements and liquidity injections.

After the financial crisis, a vast research has been carried out on the pro-cyclicality in banking considering especially the role of leverage (Adrian and Shin, 2010a; Adrian and Shin, 2010b; Baglioni et al., 2013; Damar et al., 2013; Beccalli et al., 2015; Tasca and Battiston, 2016). The milestone in this field has been the work of

[Adrian and Shin, 2010a] showing that when balance sheets are continuously marked-to-market, changes in asset price appear immediately as changes in net worth and this would algebraically lead to a decrease in leverage; however, active financial intermediaries adjust the size of their balance sheets increasing debt (especially via repos): a phenomenon known as leverage pro-cyclicality. Moreover, Adrian and Shin [2010b] find that US commercial banks had an a-cyclical leverage between 1997 and 2008, whilst the five major "pure" investment banks have a strong pro-cyclical leverage. Baglioni et al. [2013], analysing a large sample of European banks, show that pro-cyclical leverage appears to be entrenched in the behaviour of those banks for which investment banking prevails over the traditional commercial banking activity. Damar et al. [2013] using Canadian data show that positive co-movements in bank leverage and assets are associated with leverage pro-cyclicality having as a driver funding in the wholesale market (mitigated by its relative liquidity). Whilst Beccalli et al. [2015], investigating the role of off-balance sheet securitisation on US banks show that, as soon as GAAP accounting rules allowed for an under-estimation of on-balance sheet items from securitisation, effective leverage (taking into account off-balance sheet securitisation) is strongly pro-cyclical. Tasca and Battiston [2016] model the systemic risk associated with the balance-sheet amplification mechanism in a system of banks with interlocked balance sheets and with positions in real-economy-related assets. Their framework integrates a stochastic price dynamics with an active balance-sheet management aimed to maintain the Value-at-Risk at a target level and show that a strong compliance with capital requirements does not increase systemic risk unless the asset market is illiquid (in this case, even a weak compliance with capital requirements increases significantly systemic risk). In terms of interconnectedness, the last decade has seen a steady stream of attempts to measure systemic risk in an aggregate way (Acharya et al., 2010; Billio et al., 2010; Adrian and Brunnermeier, 2011; Acharya et al., 2012; Allen et al., 2012; Castro and Ferrari, 2014). Acharya et al. [2010] develop a model showing that systemic risk is equal to the product of three components: the real social costs of a crisis per dollar of capital shortage, the probability of a crisis and the expected capital shortfall of a particular firm in a crisis. Acharya et al. [2012], focusing on this third component, model the systemic expected shortfall (SES) as the propensity to be undercapitalised when the system as a whole is undercapitalised. They capture in a single measure size, leverage, interconnectedness and the co-movement of the financial firm's assets with the aggregate financial sector in a crisis and validate their findings empirically showing the ability of SES to predict the outcome of stress tests performed by regulators and the decline in equity valuations of large financial firms during the crisis. Billio et al. [2010] study systemic risk from the point of view of interconnectedness among hedge funds, banks, brokers, and insurance companies. They propose five measures of systemic risk based on statistical relations among the market returns of these four types of financial institutions and they validate their results using correlations, cross-autocorrelations, principal components analysis, regime-switching models, and Granger causality tests. Adrian and Brunnermeier [2011] propose ΔCoVar as a measure for systemic risk. CoVaR is the value at risk (VaR) of the financial system conditional on institutions being under distress; and they define each institution contribution to systemic risk as the difference between the VaR of the financial system conditional on institution being under distress and the CoVaR in the median state of the institution. Allen et al. [2012] derive a measure of aggregate systemic risk (CATFIN) that complements bank-specific systemic risk measures by forecasting macroeconomic downturns six months into the future using out-of-sample tests and perform the analysis on US, European, and Asian bank data. Castro and Ferrari [2014], using ΔCoVaR proposed by Adrian and Brunnermeier (2011) as a tool for identifying systemically important institutions, measure systemic risk by the price of insurance against financial distress. Results from their stress tests (based on ex ante measures of default probabilities and forecasted asset return correlations from high-frequency equity return data with macro-financial conditions) suggest that the theoretical insurance premium that would be charged to protect against losses that equal or exceed 15% of total liabilities (of 12 major US financial firms) stood at $110 billion in March 2008 and had an upper bound of $250 billion in July 2008.

As concerns the third stream of literature, we are interested in the current safeguards to face systemic risk in terms of regulation (Caruana, 2010; Brei and Gambacorta, 2014; Balasubramnian and Cyree, 2014; Bongini et al., 2015; Laseen et al., 2015; Moenninghoff et al., 2015), capital (Hart and Zingales, 2011; Bayazitova and Shivdasani, 2012; Black and Hazelwood, 2013; Berger et al., 2016a; Brownlees and Engle, 2016) and liquidity injections (Furfine, 2003; Armantier et al., 2015; Berger et al., 2015).

From the regulatory point of view, Caruana [2010] analyses possible policies to mitigate systemic risk as a negative externality: according to their model, in the cross-sectional dimension regulators should implement policies that seek to limit interlinkages and common exposures, whilst to face the time-dimension damages, banks have to build up capital and liquidity margins of safety during the upswing that can be drawn upon in the downturn. Brei and Gambacorta [2014] analyze how the new Basel III leverage ratio and risk-weighted regulatory capital ratio behave over the cycle. Using data from 14 advanced economies for the period 1995-2012 they find that the Basel III leverage ratio is significantly more counter-cyclical than the risk-weighted regulatory capital ratio. Balasubramnian and Cyree [2014] investigate whether or not market discipline on banking firms changed after the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010. When market discipline is improved, a lower discount for size on yield spreads, particularly for banks identified as too-big-to-fail (TBTF) or systemically important (SIFI) is observed. Using secondary market subordinated debt transactions, authors find that the size discount is reduced by 47% and TBTF discount is reduced by 94% after the DFA. In terms of market reaction towards regulatory changes, Bongini et al. [2015] investigate the reaction to the publication of the list of systemically important financial institutions (SIFI) and the new rules designed to address the too-big-to-fail problem of systemic banks. By applying event study methodology to a sample of 70 of the world's largest banks, results show that financial markets did not univocally react to the new regulation regarding SIFIs. However, markets discriminated between high and low capitalised banks and they correctly estimated the probable effects of the additional capital requirements. Along the same field but with different results, Moenninghoff et al. [2015], analysing the stock price reactions for the 300 largest banks from 52 countries across 12 relevant regulatory announcements and designation events, provide evidence on how the new international regulation on Global Systemically Important Banks (G-SIBs) impacts the market value of large banks. They observe that the new regulation negatively affects the value of the newly regulated banks; however, government ownership of banks supports the view that the positive reaction to these designations can be attributed to a Too-Big-to-Fail (TBTF) perception by investors. Laseen et al. [2015] analyze if stricter policy-interventions (an increase in interest rates) reduce systemic risk because output, inflation, asset prices should decrease. Their findings show that when asset prices decrease, returns decrease too and banks are unable to raise equity. This inability leads them to increase debt and subsequently systemic risk.

Hart and Zingales [2011] design a capital requirement for large financial institutions (LFIs) mimicking the operation of margin accounts. As concerns the relation between the Treasury's Capital Purchase Program and systemic risk, Bayazitova and Shivdasani [2012] study the effects and the incentives of banks to participate in the Capital Purchase Program (CPP). The authors show that stronger banks opted out of participating in CPP and that equity infusions were provided to banks that posed systemic risk, faced high financial distress costs, but had strong asset quality. In the same line, Black and Hazelwood [2013], study the effects of TARP capital injections program on bank risk-taking by analysing the risk ratings of banks' commercial loan originations during the crisis. Their results indicate that, relative to non-TARP banks, the risk of loan originations increased at large TARP banks but decreased at small TARP banks. Berger et al. [2016a] study how regulatory interventions and capital support affect the risk taking and liquidity creation of troubled banks and find that regulatory interventions and capital support both succeed in reducing bank risk taking. Brownlees and Engle [2016] using Tobit regression and data from the Treasury recapitalization program (TARP) assess the significance of SRISK as a predictor of Treasury's injections.

Concerning Fed's liquidity facilities, Furfine [2003] analyses how banks rely on standing facilities by central banks depending on how financial institutions lend to one another overnight. Author shows that the mere availability of central-bank-provided credit may lead to its use being greater than what would be expected based on the characteristics of the interbank market. By contrast, however, banks may perceive a stigma from using such facility -DW- (because the improper design of the facility might decrease a bank's incentive to participate), and thus borrow less than what one might expect, thereby reducing the facilities' effectiveness at reducing interest rate volatility. Armantier et al. [2015] provide empirical evidence for the existence, magnitude, and economic cost of stigma associated with banks borrowing from the Federal Reserve's Discount Window (DW) during the 2007-2008 financial crisis. In particular, authors find that banks were willing to pay a premium of around 44 basis points across funding sources to avoid borrowing from the DW. Whilst **?** compare the Federal Reserve liquidity injections into banks during the recent financial crisis using the Discount Window and Term Auction Facility. Their findings show that: small bank users were generally weak (while large bank users were not) and the funds were weak substitutes to other funding sources. Overall, these facilities increased aggregate lending, enhancing lending at expanding banks and reducing decline at contracting banks (where small banks increased small business lending, while large banks enhanced large business lending). Loan quality only improved at small banks, while both left loan contract terms unchanged.

Our study arises essentially by combining the above streams of literature together with the recent evidence on the increase in bank size and in interbank debt; particularly, we study how, given the high degree of interconnectedness of today's banking system, even a small fraction of banks with a pro-cyclical leverage can impose a large social cost in terms of systemic risk and interconnectedness.

2.3 Institutional background and identification strategy

Motivations. Provided that assets (A) are evaluated at *fair value* (even known as *marked to market*) and that debt (D) cannot be renegotiated in the short-run[2], in $t = 0$ the bank's balance sheet appears like:

$$A_0 = E_0 + D_{acc}$$

whilst for $t > 0$ it becomes:

$$A_{fv} = E_{fv} + D_{acc}$$

This immediately translates into the definition of "quasi-market leverage ratio" and it is straightforward to see that an increase in assets should be associated with a decrease in leverage.

$$LEV = \frac{A_{fv}}{E_{fv}} = \frac{A_{fv}}{A_{fv}-D_{acc}}$$
$$\frac{\partial LEV}{\partial A_{fv}} = -\frac{D_{acc}}{(A_{fv}-D_{acc})^2} < 0$$

However, Adrian and Shin (2010), in their first seminal work on this topic, proved that an increase in *fair value* of assets leaves room for an increase in debt for banks which operate by way of leverage targeting: commercial banks. Moreover, leverage is pro-cyclical (or $\frac{\partial LEV}{\partial A_{fv}} > 0$) for those banks which actively manage leverage due

[2]In fact, if is easy to evaluate the market value of equity and the stock price (at least for listed firms), computing the value of debt is not so straightforward because only part of debt is traded and analysts should rely on total borrowings observed only in periodic accounts.

to their incentives in increasing debt during financial bubbles: typically, investment banks. Secondly, they motivated their findings with the fact that banks target equity as a function of VaR in order to be solvent or to have a particular level of credit rating, like: $E = \lambda VaR$. In this way, a decrease in the Unit Value at Risk leaves room to an increase in debt in order to keep this ratio constant. [3]

As a consequence, an increase in assets (when they are valued at *fair value*) lead to an increase in debt from two perspectives: leverage targeting and from the decrease in the Unit Value at Risk. Figure 2.1 (in Section 2.7) shows how the increase (decrease) in assets is followed up by the increase (decrease) in leverage for the period under analysis (where the degree of co-movement among the two variables is stronger starting from the first quarter of 2010).

On the other side, the recent financial crisis has highlighted how the financial system's incentives to take ex-ante excessive correlated risks, mainly in credit booms and asset price bubbles, might have serious backlash against other financial intermediaries and the real economy. In fact, from leverage pro-cyclicality, if the adjustment in leverage through short-run debt occurs by interbank debt (correlated risk) it is easy to see how the previous problem might be exacerbated and how growth in bank assets and increased systemic risk are two sides of the same coin. In fact, imagine a boom where the assets of both banks double in size, but the pool of retail deposits stays fixed (as standard in the literature -Shin [2010]-, core liabilities grow slowly in line with household wealth). Then, the proportion of banking sector liabilities in the form of retail deposits must fall. In other words, rapidly expanding bank assets is mirrored by the increased cross-claims across banks (Shin, 2010; Faia and Ottaviano, 2015). Thus, during a boom when bank assets grow rapidly, intermediaries lend and borrow from each other much more than during normal periods: in this way solvency and liquidity often feed each other (Rochet and Vives, 2004; Diamond and Rajan, 2009). Figure 2.2 (in Section 2.7) shows the relation between the increase in assets and the increase in systemic risk for the period under consideration, and reveals that the magnitude of the co-movement among them is larger starting from the third quarter of 2007. From VaR perspective, as studied in depth by both empirical and theoretical works (Estrella, 2004; Gambacorta and Mistrulli, 2004; Repullo and Suarez, 2013), we saw that leverage increases following the decrease of Unit VaR; banks target their capital as a function of their individual risk without taking into account the social cost that they impose on the system: resulting, in this respect, as under-capitalised banks. Thus, banks with lower capital than the amount sufficient to conduct business have no buffers to face economic down-turn which might lead to higher systemic risk.

[3]Substituting this into the definition of leverage, we get:

$$LEV = \frac{A_{fv}}{E_{fv}} = \frac{A_{fv}}{\lambda VaR} = \frac{1}{\lambda}\frac{1}{V}$$

where V is defined as Unit Value at Risk ($V = \frac{VaR}{A_{fv}}$) and we can immediately see that:

$$\frac{\partial LEV}{\partial A_{fv}} = \frac{\partial LEV}{\partial V} * \frac{\partial V}{\partial A_{fv}} > 0$$

In order to consider the effects of leverage pro-cyclicality on systemic contribution of a bank we employ SRISK measure by Brownlees and Engle (2012). SRISK captures the capital shortfall of a bank conditional on a severe market decline as a function of its size, leverage and risk and it represents the amount of capital that a bank would need to raise in order to function normally. In particular, they define the Capital Shortfall as the cases in which banks do not meet regulatory capital requirements[4]:

$$CS = \kappa\mathbb{E}[A_{fv}|Crisis] - \mathbb{E}[E_{fv}|Crisis] > 0$$

where the first term represents the capital requirement (and κ the regulatory parameter) and the second term represents the actual capitalization. This is equivalent to (provided debt cannot be renegotiated):

$$CS = \kappa(D_{acc} + \mathbb{E}[E_{fv}|Crisis]) - \mathbb{E}[E_{fv}|Crisis] > 0$$

The authors define *Crisis* or *Systemic event* the market decline below a threshold C over a time horizon h: $\{R_{m,t+1:t+h} < C\}$ and SRISK the expected Capital Shortfall (for financial institution i) conditional on that event. Previous equation becomes:

$$SRISK_{i,t} = \mathbb{E}[CS_{i,t+h}|R_{m,t+1:t+h} < C]$$

The capital shortfall can be directly calculated by recognising that the book value of debt will be relatively unchanged during short time-periods while equity values fall by LRMES (Long Run Marginal Expected Shortfall). Incorporating previous equations:

$$SRISK_{i,t} = \kappa D_{acc} - (1-\kappa)\mathbb{E}[E_{i,t}|R_{m,t+1:t+h} < C]$$

or,

$$SRISK_{i,t} = \kappa D_{acc} - (1-\kappa)E_{i,t}(1 - LRMES_{i,t})$$

Recalling that $D_{acc} = E_{fv}(LEV - 1)$ and substituting we can write previous equation as:

$$SRISK_{i,t} = E_{i,t}[\kappa LEV_{i,t} + (1-\kappa)LRMES_{i,t} - 1]$$

where LEV is the quasi-market leverage ratio and LRMES is the Long Run Marginal Expected Shortfall.[5]

[4] $\frac{E_{fv}}{A_{fv}} \geq \kappa$; where κ is the prudential level of equity relative to assets.

[5] That is, $-\mathbb{E}_t[R_{i,t+1:t+h}|R_{m,t+1:t+h} < C]$.

At this point it is straightforward to see that $SRISK_{i,t} = f(E_{i,t}; LEV_{i,t}; LRMES_{i,t})$ and it increases directly when leverage increases by $\frac{\partial SRISK_{i,t}}{\partial LEV_{i,t}} = \kappa E_{i,t} > 0$. Figure 3 (in Section 7) shows this evidence and how this relation becomes stronger over time. However, this represents a lower bound, because in this case we are assuming that the partial derivatives of $LRMES_{i,t}$ wrt to $LEV_{i,t}$ is zero, that is the co-movements between leverage and market returns are not influenced by smaller changes in leverage. At this point the aim of this chapter is trying to see which is the effect of an increase in assets on systemic risk: on one hand, we would expect that larger banks contribute more to systemic risk because greater would be their social cost in case of failure (that is a positive impact on LRMES which would lead to an increase in systemic risk); on the other hand, considering that leverage should decrease following an increase in assets, by chain rule we would expect that:

$$\frac{\partial SRISK_{i,t}}{\partial A_{i,t}} = \frac{\partial SRISK_{i,t}}{\partial LEV_{i,t}} * \frac{\partial LEV_{i,t}}{\partial A_{i,t}} = \frac{-(\kappa E_{i,t})D_{acc}}{(A_{fv} - D_{acc})^2} < 0$$

Meanwhile, we cannot disregard findings from Adrian and Shin (2010) and the effects on Systemic Risk may be amplified once we consider that leverage is pro-cyclical: thus, an increase in assets would have a direct effect via an increase in LRMES and an indirect effect considering the increase in leverage. In other words, the higher the leverage of the bank, the higher are the incentives of the bank to be more interconnected.

With the purpose to analyze this combined effect we take the first order approximation of the percentage change in LEV relative to LEV_0 as A change around A_0 and the first order approximation of the percentage change in SRISK relative to $SRISK_0$ as LEV change around LEV_0. If we consider debt (D_{acc}) as constant we have:

$$\hat{lev} = (\frac{-D_{acc}}{A - D_{acc}})\hat{a}_{i,t}$$

While, when we consider the results from Adrian and Shin (2010) with respect to an increase in debt when assets increase, the log-linearisation would be:

$$\hat{lev} = \frac{D_{acc}}{D_{acc} - A}(\hat{d}_{i,t} - \hat{a}_{i,t})$$

Whilst the log-linearisation of SRISK results in:

$$\hat{srisk} = \hat{e}_{i,t} + \frac{1}{\Gamma}[\kappa LEV * \widehat{lev} + (1-\kappa)LRMES * \widehat{lrmes} + LEV * LRMES(\kappa - 2\kappa^2)\hat{\kappa}]$$

where Γ is defined as $[\kappa LEV + (1-\kappa)LRMES - 1]$.[6]

Now it is easy to see how an increase in leverage immediately translates into larger systemic risk; however, since

[6] Imposing the SRISK measure=0 is easy to see that when LRMES increases, equity should increase to satisfy the threshold.

we are studying how pro-cyclicality of leverage is translated into pro-cyclicality of systemic risk, the final effect may be exacerbated or mitigated depending on the other forces: LRMES, equity and capital regulation (κ).

With this purpose, we explore the interaction among SRISK and leverage for four sub-samples of banks. First, we look at those banks that have participated into Federal Reserve's liquidity injection programs geared for individual depository institutions and for the banking system as a whole by providing a reliable backup source of funding (Discount Window[7] and Term Auction Facility).[8] Both facilities concern collateralised lending with some differences: DW represented an overnight facility (mainly renewed) whilst TAF had 28-84 days maturity, DW was a tap program -that is, credit has no limits provided that banks had sufficient collateral- while TAF was auction-based (with a precise amount offered by the Federal Reserve, a minimum number of participants in the auction and limits on the amount each bank can bid) implying differences in the price of credit. Figure 5 (Section 7) shows that rates under TAF (where banks had to bid for funds) were perfectly in line with rates on the market, whilst DW rate was on average 60bp above the market (on average, not distinguishing between primary and secondary credit). As stated by Bayazitova and Shivdasani [2012] these capital injections may be considered a multiplier for LRMES, that is capital needed by those banks during the crisis. Secondly, we investigate the sub-sample of banks defined by regulators as Global-Systemically Important Financial Institutions or Domestic-Systemically Important Financial Institutions: on one hand, these banks are those identified by the regulators for having the largest capital shortfall ($[\frac{\partial SRISK}{\partial LRMES}|Sifi] > [\frac{\partial SRISK}{\partial LRMES}|Others]$) but, on the other hand, they are subject to higher capital requirements and continuous monitoring via stress test (Supervisory Capital Assessment Program). Moreover, banks which are considered as *systemic* have incentives in seeking greater dimension and interconnection in order to get an implicit insurance represented by the status of TBTF or TITF. Thirdly, we investigate how leverage pro-cyclicality translates into pro-cyclical systemic risk for the sub-sample of banks defined to be under "regulatory pressure" (*Reg. Pressure*). We specify these banks as those having a ratio between equity and risk weighted assets below the regulatory lower bound ($\frac{E}{RWA} < \kappa$) and we define as a threshold for $\kappa = 8\%$. Lastly, we concentrate our analysis on banks participating into the Treasury's Capital Purchase Program (CPP). As part of the first stage of the TARP program, the U.S. Treasury announced on October 13, 2008, that it would invest directly in equity of financial institutions. On October 14, 2008, CPP was announced, allocating $250 billion for purchases of preferred stock of U.S. financial institutions.[9] Under

[7] Starting from the revision of August 2007, the Discount Window provides liquidity under three programs: Primary credit (at a rate 50bp above FOMS -Federal Open Market Committee target rates- is a "no asked question" for sounder banks), Secondary credit (at a rate 100bp above the FOMC has the aim to solve liquidity problems at bank level and cannot be use for expansion of borrower assets) and the seasonal credit. 82% of banks in our sample relied on Primary credit. Generally the FOMC rate ranged from 0.25 to 0.50 bp and the corresponding primary rate and secondary rates from 0.75 to 1 and from 1.25 to 1.50 respectively.

[8] Even if the Court (endorsed by Bernanke) sustained that information on borrowers from these funds should not be released, by fear of negative consequences in the financial markets, Bloomberg LLP encouraged their disclosure under Freedom of Information Act (FOIA); data on DW are published quarterly with two years lag starting from 22nd July 2010 whilst TAF was active from December 2007 to March 2010 and information on borrowers have been released in the second quarter of 2010 under the Dodd-Frank Consumer Protection Act.

[9] On this day, nine financial institutions 'Citigroup, Wells Fargo, JPMorgan, Bank of America, Goldman Sachs, Morgan Stanley, State Street, Bank of New York Mellon, and Merrill Lynch received an aggregate infusion of $125 billion. Other banks had until

CPP, the U.S. Treasury purchased non-voting preferred stock, and banks could apply for this capital injection in amounts between 1% and 3% of their risk-weighted assets (CPP infusions took the form of preferred stock in order to be attractive to banks by virtue of being non-dilutive to common shareholders). Under CPP-TARP program the U.S. Treasury would also receive warrants with a ten-year life to purchase common stock for an amount equal to 15% of the preferred equity infusion. The dividend on the preferred stock was set at 5%, but it would rise to 9% after three years. However, CPP infusions forbade dividend increases on common shares until the preferred shares were repaid.[10]

The identification strategy: leverage pro-cyclicality. In the first stage of the analysis, in the spirit of Adrian and Shin (2010), we replicate their model testing the following equation:

$$\Delta ln(Lev_{i,t}) = \alpha + \beta_1 ln(Lev_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \alpha_i + \epsilon_{i,t} \tag{2.1}$$

where $\Delta ln(Lev_{i,t})$ and $\Delta ln(TA_{i,t})$ represent the increase in leverage and assets from *t-1* and *t* for bank *i*. That is, when assets are evaluated at *fair value*, if banks actively manage their leverage we expect a positive coefficient for β_2. We test this hypothesis via fixed-effect regression with bank fixed effects (in order to take into account cross-sectional differences among banks) and year-quarter fixed effects in order to consider quarter seasonality and time trends. We perform robustness test controlling for Federal Reserve district fixed effects. Since we are interested in the effects on changes in leverage resulting from changes in assets, following Adrian and Shin [2010b], the panel regression is performed in first-differences. Running a regression in first-differences wipes out time invariant omitted variables using the repeated observations across time. As long as $E[\Delta ln(TA_{i,t})|\Delta\varepsilon_{it}] = 0$ the estimator is unbiased and consistent and this assumption is less restrictive than the assumption of weak exogeneity required for unbiasedness using the FE estimator in levels. Several researchers argue that the use of differenced-equation for modelling purpose is problematic and one of the main reason includes the presumed biases that result if the correlation between the initial level of a dependent variable and its change is not explicitly modelled; for this reason, and as consolidated in the literature Imbens and Wooldridge [2009], we include as a predictor the lagged-level of the dependent variable (typically referred to "stability component"). Moreover, under mean-reversion, the higher the leverage in the previous period the lower will be the increase this year. Dynamic models of behaviour have a possible justification for the inclusion of initial level of the dependent variable on the right-end side of a change equation: they guarantee unconfoundedness and eliminate autocorrelation in the model.[11]

November 14, 2008, to apply for CPP funds from the U.S. Treasury. Moreover on 19th December 2008, the US Treasury Department purchases a total of $27.9 billion in preferred stock in 49 US banks under the Capital Purchase Program.

[10] Along with CPP, government guarantees on new bank debt issues and an increase in FDIC guarantee of non-interest bearing transaction accounts were also unveiled on October 14, 2008. The bank debt guarantee was finalised on November 21, 2008, as the Temporary Liquidity Guarantee Program (TLGP).

[11] Particularly, we assume that the state-art time t is a function of the initial level of the system: such models are termed "non-ergodic" in the sense that the past cannot be forgotten and we should take into account previous conditions.

$H1_n$: the coefficient β_2 in model (1) is negative meaning that an increase in the market value of total assets does not lead to an increase in leverage.

Graphs 2.6(a), 2.7(a), 2.8(a) and 2.9(a) in Section 7 show, through a scatter, the degree of pro-cyclicality of leverage as a function of the change in the logarithm of market value of assets with respect to the previous quarter for each group of banks considered in the analysis: those participating in the liquidity facilities activated by the Federal Reserve, SIFIs, banks under Regulatory Pressure and banks participating in the Treasury's Capital Purchase Program. Motivated by Figures 2.6(a), 2.7(a), 2.8(a) and 2.9(a), we investigate if differences in pro-cyclicality of leverage are not only due to the preferences among investment or commercial banking activities (Adrian and Shin, 2010b; Baglioni et al., 2013), but also to liquidity problems that banks are suffering or have suffered during the financial crisis and/or the regulatory framework that they have to be compliant with. Particularly, Figures 6(a) and 7(a) show that for the groups of banks participating into Federal Reserve's liquidity injection programs and for *SIFIs* banks, the increase in assets leads to an increase in leverage greater than the pro-cyclicality observed for the baseline group, whereas Figure 9(a) shows that for *CPP banks* leverage is still pro-cyclical but the magnitude is expected to be lower than in the baseline group. Surprisingly, Figure 8(a) exhibits counter-cyclical leverage for the group of banks under *regulatory pressure* defined as banks with a ratio of equity over risk weighted assets below 8%. In this respect, we test hypothesis 2 via the following set of regressions.

$$\Delta ln(Lev_{i,t}) = \alpha + \beta_1 ln(Lev_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \beta_3 * I_{i,t} + \beta_4 \Delta ln(TA_{i,t}) * I_{i,t} + \alpha_i + \epsilon_{i,t} \tag{2.2}$$

Where I represents an indicator variable for different sub-samples of banks: those participating into Federal Reserve's liquidity injection programs (*LOLR*), banks identified as Systemically Important Financial Institutions (*SIFIs*), banks under regulatory pressure (*Reg. Pressure*) and banks participating into the Treasury's Capital Purchase Program (*CPP banks*).

$H2_n$: Banks belonging to sub-samples of LOLR, SIFIs, Reg. Pressure and CPP banks are not different in terms of pro-cyclicality of leverage; thus, coefficients β_3 and β_4 should be not statistically significant in all specifications of regression (2).

Economic theory (Kiyotaki and Moore, 1995; Kiyotaki and Moore, 2002) and anecdotal evidence suggest that booms are periods characterised by an over-evaluation of assets whilst during burst prices decrease. If previous equations are confirmed, we expect that banks increase their leverage in "good periods" while they deleverage in "bad periods" showing a positive coefficient for β_2. However, once we test that the growth rate of assets and the growth rate of leverage move in the same direction (both during booms and during bursts) their magnitude might be different. Figure 1 (Section 7) shows how the overlapping between the change in leverage and assets differs along years and quarters. During downturn, being compliant with the regulatory framework, the squeeze in wholesale funding and the gradual drawdown of line of credits previously committed are all motivations that might sum up making the deleveraging process more severe. In order to check for differences among the crisis and no-crisis period we test equation (3) along two sub-periods. The same hypothesis is tested for banks belonging to sub-samples of *LOLR*, *SIFIs*, *Reg. Pressure* and *CPP banks.*

$$\begin{aligned} Crisis: \Delta ln(Lev_{i,t}) &= \alpha + \beta_1 ln(Lev_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \alpha_i + \epsilon_{i,t} \\ No-crisis: \Delta ln(Lev_{i,t}) &= \alpha + \beta_1 ln(Lev_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \alpha_i + \epsilon_{i,t} \end{aligned} \tag{2.3}$$

$H3_n$: Banks do not show differences in terms of the magnitude of the coefficient associated to the growth rate of total assets among the crisis and no-crisis period.

As stated by a growing literature (Diamond and Rajan, 2005; Crotty, 2009) and confirmed by the financial crisis, liquidity shortages played a major role in the propagation of the financial crisis. During booms, short-term debt has been a way to boost balance sheets and increase leverage: typically short-term debt is cheaper due to short maturity and because it is usually collateralised. In order to test this hypothesis we analyze how previous results change when we proxy the increase in assets specifically as an increase of different kinds of short-term debt. We consider, among others, the change in the logarithm of repurchase agreements with other banks (*repo*), repo signed with the US central bank (*FedRepo*), short-term deposits in other banks as measure of wholesale financing (*Interbank*), standing issue of commercial paper (*Com.Pap.*) and participation in Federal Reserve's liquidity injection programs (*LOLR*, like Term Auction facility and Discount Window)[12]. In what concerns short-term financing, Figure 4 shows that, before the crisis -the third quarter of 2007-, during the "boom" period there has been an increase in all kinds of short-term debt: repos, repos with the Federal Reserve and commercial papers. However, we notice that, starting from the fourth quarter of 2007, the wholesale market started to fluctuate with a negative spike in the third quarter of 2008 when the interbank market began to freeze showing a reduction in *repo* and *reverse repo* -red lines-; meanwhile there has been a decrease in the credit granted by banks to the Federal Reserve via a contraction in reverse repo having as counterpart the US central bank (*FedReverseRepo*). During the same period, banks continued to rely on commercial paper financing -*Com.Pap.*- and to be short-term indebted with the Federal Reserve (*FedRepo*) evidencing a positive spike exactly in the fourth quarter of 2008. While, starting from the last quarter of 2008 the deleveraging

[12]When LOLR figures as dependent variable we exclude it from the set of regressors.

process concerned even repo and commercial paper financing confirming a decrease in short-term financing via "conventional ways". Moreover, Figure 4 shows a downward spike in *Repo* and an increase in *FedRepo* exactly after the activation of Term Auction facility program (2007q4). Thus, enlarging the possibilities of short-term financing with respect to Adrian and Shin [2010b], whom consider mainly *repo* financing, we take into account issuing of commercial paper, the injection of liquidity from the Federal Reserve -via the DW or TAF programs- and the interbank market as alternative sources of funding in the short-run. We perform this analysis testing the following regression:

$$\begin{aligned}\Delta Lev_{i,t} =&\alpha + \beta_1 ln(Lev_{i,t-1}) + \beta_2 LOLR_{i,t} + \beta_3 \Delta ln(repo_{i,t}) + \\ &\beta_4 \Delta ln(FedRepo_{i,t}) + \beta_5 \Delta ln(Com.Pap._{i,t}) + \beta_6 \Delta ln(Interbank_{i,t}) + \alpha_i + \epsilon_{i,t}\end{aligned} \tag{2.4}$$

$H4_n$: We exclude as one of the drivers of the growth rate of leverage the increase in short-term financing via repos, repos with the Federal Reserve, commercial papers, wholesale debt or participation in Fed's liquidity injection programs.

Moreover, this prediction is supported by the path in interest rates. Figure 5 shows that bid-rates on TAF were perfectly in line with rates on commercial paper and federal funds rates but borrowing from this program had the advantage of "anonymous borrower" (at least until the Dodd-Frank Act become effective in July, 21st 2010) making it a first-best solution for banks trying to avoid the disclosure of their name as Federal Reserve's borrower Cyree et al. [2013]. The aim of regression (4) is to verify, controlling for the increase in repo, if there has been an increase in leverage subsequent the applications to DW or TAF programs or other short-term borrowings and how this is translated in the degree of leverage pro-cyclicality. In other words, we investigate if these sources of short-term debt feed each other or they are substitutes in the market for liquidity.
To summarise, as short-term funding tends to be the cheapest way to increase debt it is reasonable to predict that the increase in leverage happens via short-term borrowing. In this way, the growth in non-core liabilities via short-term debt are all consequences of the rapid growth of bank assets during boom. To the extent that the ratio of non-core to core liabilities reflects the stage of the financial cycle, it also reflects the degree of risk-taking by the banking sector and the extent of under-pricing of risk. Risk is being under-priced in the sense that banks take cues from current buoyant market conditions to take on additional exposures, without taking sufficiently account of the fallout to the rest of the economy when the bubble eventually bursts (negative externality). The possibility that banks take account of their own short-term objectives without taking account of the spillover effects of their actions on other banks and on the economy as a whole, lead us to conduct the analysis on systemic risk pro-cyclicality.

The identification strategy: systemic risk pro-cyclicality. Laeven et al. [2015] motivate the presence of agency conflicts in large organizations and "too big to fail" considerations to prove that individual and systemic risk are inversely related to bank capital. Consistently with their findings, in the second stage of the analysis we test whether the increase in fair value of assets causes a shift in the risk appetite of financial institutions. The motivation for this question arises from the evidence that on one hand, larger banks aim at reaching the *status* of TBTF or TITF in order to benefit from the implicit guarantee associated with public rescue (Rochet, 1996; Demsetz and Strahan, 1997) but, on the other hand, the increase in market value of assets may be associated with a reduction in systemic risk as long as banks increase their capital, their diversification, their liquidity buffer and reduce their degree of interconnection: that is, when an increase in assets does not increase LRMES. We test pro-cyclicality of systemic risk by the following equation.

$$\Delta SRISK_{i,t} = \alpha + \beta_1 ln(SRISK)_{i,t-1} + \beta_2 \Delta ln(TA)_{i,t} + \alpha_i + \epsilon_{i,t} \tag{2.5}$$

$H5_n$: the coefficient β_2 in model (5) is not statistically significant meaning that an increase in assets valued at fair value does not lead to an increase in systemic risk.

Following we ask whether the degree of pro-cyclicality among fair value of assets and systemic risk (if any) is the same along four sub-samples of banks. As before, we investigate the effects on banks participating into Federal Reserve's liquidity injection programs (*LOLR*), *SIFIs*, low capitalised banks (*Reg. Pressure*), and banks which relied on TARP funds (*CPP banks*).

$$\Delta ln(SRISK_{i,t}) = \alpha + \beta_1 ln(SRISK_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \beta_3 * I_{i,t} + \beta_4 \Delta ln(TA_{i,t}) * I_{i,t} + \alpha_i + \epsilon_{i,t} \tag{2.6}$$

$H6_n$: Banks do not show differences in the degree of pro-cyclicality of systemic risk along the four groups of banks.

As for pro-cyclicality of leverage we test whether an increase in total assets has different effects on the increase in systemic risk depending on the period under consideration. Figure 2 (Section 7) shows that the overlapping between changes in assets and changes in systemic risk is not homogenous: particularly, it seems that the relation becomes stronger after the adoption of International Accounting Standard Rules with some differences among the crisis (downturn) and no-crisis periods (upturn).

$$\begin{aligned} Crisis: \Delta ln(SRISK_{i,t}) &= \alpha + \beta_1 ln(SRISK_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \alpha_i + \epsilon_{i,t} \\ No-crisis: \Delta ln(SRISK_{i,t}) &= \alpha + \beta_1 ln(SRISK_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \alpha_i + \epsilon_{i,t} \end{aligned} \tag{2.7}$$

$H7_n$: Banks do not show differences in terms of direction and magnitude of the effects of the growth in assets on systemic risk among the crisis and no-crisis period.

Moreover, large BHCs, while better diversified than small BHCs, may have used their diversification advantage to operate with lower capital ratios and pursue riskier activities (Demsetz and Strahan,1997). As previous evidence has shown that banks targeting leverage have space for increasing debt when *fair value* of assets increases, symmetrically this happens for systemic risk. Defining systemic risk (as in Brownlees and Engle, 2012) as the price of the negative externality of banks when their equity value falls below the Basel-II compliant threshold (*Capital Shortfall*) we can notice that banks may target their systemic risk.

$$SRISK_{i,t} = min[0; CS_{i,t}]$$

$$SRISK_{i,t} = min[0; E_{fv} - \kappa(E_{fv} + D_{acc})]$$

Which, recalling the quasi-market leverage ratio, may be written as:

$$SRISK_{i,t} = min[0; \frac{E_{i,t}}{A_{i,t}} - \kappa\frac{(E_{i,t}+D_{acc})}{A_{i,t}}]$$

$$SRISK_{i,t} = min[0; \frac{1}{Lev_{i,t}} - \kappa]$$

When κ is equal to Basel II capital requirement (8%), this might be evaluated as a short put option having as a strike price κ and as underlying $\frac{1}{Lev_{i,t}}$. Thus, we can predict that as long as $\frac{1}{Lev_{i,t}}$ is below the regulatory threshold there is room for banks to increase leverage without increasing systemic risk. We test this hypothesis via regression (9) for all our sub-samples of banks.

$$\begin{aligned} Lev < 12.5 &: \Delta ln(SRISK)_{i,t} = \alpha + \beta_1 ln(SRISK_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \epsilon_{i,t} \\ Lev \geq 12.5 &: \Delta ln(SRISK)_{i,t} = \alpha + \beta_1 ln(SRISK_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \epsilon_{i,t} \end{aligned} \tag{2.8}$$

$H8_n$: Banks do not show differences on the degree of pro-cyclicality of systemic risk depending on the relation among leverage and the regulatory capital threshold.

Thus we expect evidence for systemic risk pro-cyclicality when the inverse of time-varying leverage is above the regulatory capital threshold, while below it banks might have pro-cyclical leverage still targeting systemic risk to zero.[13]

[13] Put in another way, we can see that the bank safety-condition in terms of Capital Shortfall ($E_{i,t} - \kappa(E_{i,t} + D_{acc}) \geq 0$) is expressed as: $E_{i,t} \geq \frac{\kappa}{1-\kappa}\frac{1}{1-LRMES_{i,t}} * D_{acc}$.

Structural equation. To properly study the pro-cyclicality of systemic risk we need to take into account the results from Adrian and Shin (2008). Given that the growth rate in assets, $\Delta ln(TA_{i,t})$, affects both the growth rate of leverage and the growth rate of systemic risk via the growth rate of leverage, we need to shape these effects on two endogenous variables to avoid spurious correlation.[14] In order to tackle this issue, we perform firstly a simultaneous equation model (allowing for correlation among dependent variables) and secondly a structural equation model (via Three Stage Least Squares)[15].

Particularly, we model the simultaneous equations in order to check for the mediation effect of leverage on systemic risk, introducing the effect of our main exogenous variable, $\Delta ln(TA_{i,t})$, on both endogenous variables and considering that the error terms of $\Delta ln(Lev_{i,t})$ and $\Delta ln(SRISK_{i,t})$ might be correlated. In regression (9), we model $\Delta ln(TA_{i,t})$ to affect both leverage and systemic risk allowing for correlation among our dependent variables and for different effects depending on sub-samples of banks (*LOLR, SIFIs, Reg. Pressure* and *CPP banks*). With simultaneous equations we estimate unknown parameters by minimising the difference among observed and implied covariance matrix via maximum likelihood estimation. The number of observations allows for model specification (resulting in unique estimates) whereas disentangle the effect of the exogenous increase in assets depending on different sub-samples of banks allows for model identification. In this way we include indicator variables for each sub-sample in order to consider attrition among groups.

$$\begin{cases} \Delta ln(Lev_{i,t}) = \alpha + \beta_1 ln(Lev_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \beta_3 * I_{i,t} + \beta_4 \Delta ln(TA_{i,t}) * I_{i,t} + \epsilon_{i,t} \\ \Delta ln(SRISK_{i,t}) = \alpha + \beta_1 ln(SRISK_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \beta_3 * I_{i,t} + \beta_4 \Delta ln(TA_{i,t}) * I_{i,t} + \epsilon_{i,t} \end{cases} \tag{2.9}$$

In order to confirm our results we made explicit comparison with a competing model controlling for exogenous variations (Duncan, 1975). In this respect, we perform a structural equation model via Three Stages Least Squares (3SLS) which allows for leverage endogeneity and for Granger causality test with panel data. Three-Stages Least Squares (3SLS) estimates a system of structural equations, where $\Delta(SRISK_{i,t})$ equation contains, among the explanatory variables, the endogenous variable $\Delta(Lev_{i,t})$ which is the dependent variable from another equation in the system.[16] This model is perfectly suited to the case in which a variable is the sum of an exogenous variable and a dependent variable (which might appear as an explanatory variable in some equations). The effects of the increase in the value of total assets on the endogenous variable $\Delta(Lev_{i,t})$ is identified by the exogenous variation in the log-level of leverage in the previous period, and macro-economic or financial indicators which might affect the path in this variable. Particularly, we shape the path for the change in

[14] It is straightforward sustaining that the movement in systemic risk and leverage represents a perfect case of cointegration however, as before, expressing regressions as first-differences allows for a proper specification in terms of covariance stationary (VECM form).

[15] We report results from structural equation model, results from simultaneous equations are available upon request.

[16] All dependent variables are explicitly taken to be endogenous to the system and are treated as correlated with the disturbances in the system's equations. Further, because some of the explanatory variables are the dependent variables of other equations in the system, the error terms among the equations are expected to be correlated.

leverage with the level of the Treasury rate (*Treasury rate*), the percentage change in GDP (*GDP*), the average rate paid by banks on commercial paper in order to proxy the cost to increase debt via commercial paper (*CP rate*), the average rate of return of public government indebtedness on the market proxied by the MSCI 10y Gov. Bond index (*Bond Index*), the logarithm of securities pledged as collateral (*Pledged Sec.*) and a dummy variable distinguishing between the crisis and no-crisis period (*crisis*); while the effects of the increase in the fair value of assets on the endogenous variable $\Delta(SRISK_{i,t})$ is identified by the exogenous variation of the autoregressive term of the dependent variable (in logarithm), a dummy variable indicating if the Dodd-Frank Act is entered into force (*DFA*), the percentage change in GDP with respect to the previous quarter (*GDP*), the CPI index in order to control for US inflation (*Cpi*), the change in the return and volatility of the US market proxied by the log-differenced value of the total return index of the S&P500 (*S&P*) and the VIX (*Vix*) respectively, and a dummy variable distinguishing between the crisis and no-crisis period (*crisis*). Among the set of exogenous regressors for the change in systemic risk we further consider the logarithm of the share of assets in the form of loans to US banks (*Loans US banks*) -in order to proxy interconnectedness with the banking system-, and the share of domestic to consolidated assets (*Domestic A.*). The description of the exogenous variables in the vector $\mathbf{X_{i,t}}$ is explained in the following section.

$$\begin{cases} \Delta ln(Lev_{i,t}) = \alpha + \beta_1 ln(Lev_{i,t-1}) + \beta_2 \Delta ln(TA_{i,t}) + \beta_3 * I_{i,t} + \\ \qquad \beta_4 \Delta ln(TA_{i,t}) * I_{i,t} + \beta_5 \mathbf{X_{i,t}} + \epsilon_{\mathbf{i,t}} \\ \Delta ln(SRISK_{i,t}) = \alpha + \beta_1 ln(SRISK_{i,t-1}) + \beta_2 \Delta ln(Lev_{i,t}) + \beta_3 * I_{i,t} + \\ \qquad \beta_4 \Delta ln(TA_{i,t}) * I_{i,t} + \beta_5 \Delta ln(Lev_{i,t}) * I_{i,t} + \beta_6 \mathbf{X_{i,t}} + \epsilon_{\mathbf{i,t}} \end{cases} \tag{2.10}$$

2.4 Data

Dataset. We collect quarterly data from US BHCs filling the FRY-9C from January 2002 to March 2016 and we extend this dataset in three directions. Firstly, we merge data with information on systemic risk measures as published monthly by VLAB Stern School of Business. Secondly, we include information based on the participation in the Discount Window, Term Auction Facility and Capital Purchase Program implemented by the Federal Reserve and the Treasury respectively. Thirdly, we use information on large banks as defined by the Federal Reserve Statistical Release and SIFI *status* as released by the Financial Stability Board and the Basel Committee on Banking Supervision.

Initially, our dataset includes 6,104 BHCs for the years under consideration. However, we narrow it considering only consolidated balance sheets of banks with total assets greater than 500 million of dollars filling the "BHCK" fields.[17] Thus, our final dataset comprises observations for 1635 BHCs from January 2006 to March 2016 and Table A2 in the Appendix provides details about states in which they are located. Table A3 provides the distribution of Federal Reserve districts designated to supervise the banks in the sample.[18] In order to compare the effects on leverage and systemic risk pro-cyclicality, using the same sample of banks, we exclude financial institutions that are not publicly traded because SRISK measure is based on stock market equity returns.

In order to proxy the systemic risk contribution we use the indicator proposed by Brownlees and Engle [2012] -SRISK-. The pros of this indicator encompass both the use of market prices and accounting data to infer the riskiness of an institution by measuring capital reduction following a systemic event: market prices are readily available and allow for real time measurement of risk while accounting data allows for a direct link with leverage pro-cyclicality.[19] Particularly, this measure consists of two parts: first, the cost for the society of a systemic crisis measured per dollar of capital shortage in the entire financial sector (this implies measuring the probability of a systemic crisis and the external costs of such a crisis), and a second part, which is the firm's anticipated contribution to the capital shortage in that sector (that is, measuring the expected capital shortfall of a firm in a crisis). VLAB (NY Stern School of Business) provides monthly systemic risk measures for a wide set of financial institutions including bank holding companies, insurance companies, money market funds, mutual funds, structural investment vehicles and hedge funds. From January 2006 to March 2016 VLAB has computed SRISK monthly measures for 178 institutions per year; we exclude from our analysis insurance, private equity, real estate and asset management companies leaving us with a sample of 110 institutions. Particularly, excluding those institutions we pass from a sample of 20911 bank-month observations to a sample of 14188 bank-month observations. Moreover, data were originally on a monthly basis and they have been aggregated as quarter-average leaving us with a sample of 3361 SRISK bank-quarter observations for 110 Bank Holding Companies.

The seriousness of the recent financial crisis entailed that the Federal Reserve joined the fray. The US central bank intervened with a series of programs in its role of Lender Of Last Resort (LOLR) with the aim to alleviate

[17] Beginning March 31, 2006, the FR Y-9C filing threshold was increased from $150 million to $500 million or more and FR Y-9SP filing threshold was increased from $150 million to banks with total consolidated assets of less than $500 million.

[18] We exclude from the analysis financial institutions belonging to Charter type (RSSD9048) of insurance broker or insurance companies (code 550), Employee Stock Ownership Plan (code 610), securities broker or dealer (code 700), utilities company and credit card companies without commercial bank charters (codes 710 and 720).

[19] For the sake of completeness we should point out that there are different measures of systemic risk proposed in the literature: one of them is CoVar by Adrian and Brunnermeier [2011]. We have decided to include in the analysis SRISK instead of CoVar because CoVar measure is not explicitly sensitive to size or leverage, moreover it has a lot of cross-sectional variation but it is quite stationary in the time-series dimension. The measure proposed by Bartram, Brown and Hund (2007) adopt a micro-approach as the difference between average pre-crisis and post-crisis probabilities of defaults for banks with no direct exposure to the crisis. Their use of a credit risk model, distance to default, and bank default probabilities based on equity option prices make the direct link with leverage pro-cyclicality fleeting. Other measures that proxy the methodology used to analyse credit risk model are the ones proposed by Huang, Zhou, and Zhu (2010) who use CDS and equity prices co-movements, by Puzanova and Dullmann (2013) who proxy systemic risk with a structural risk model in order to estimate banking concentration, and the one published by Vallascas and Keasey (2012) where risk of default is proxied by Merton's distance to default and it focus on liquidity requirements, non-interest income and asset growth. The measure proposed by De Jonghe (2010), the tail beta, as the probability of a decrease in bank's stock price when a banking index crash and computed via extreme value analysis conveys this measure especially suited for non-traditional banking activity and thus difficult to employ for BHCs.

liquidity problems in the short run.[20]Among them, DW (Discount Window) and TAF (Term Auction Facility) were addressed to depository institutions, saving and commercial banks. The Discount Window is a "no ask question" program (for Primary Credit), the interest rate is fixed in advance by the Federal Reserve according to the federal funds rate (FOMS, Federal Open Market Committee target rate), with no limits on the amount borrowed (provided collateral and shortcut on it); while TAF is auction-based and there are limits on the bid and on the amount offered. Provided that both programs offer liquidity in the short-term, the main difference among them is that DW is an overnight lending facility while TAF is a term one (once the bank got funds with TAF, the borrower cannot repay them before the maturity, in other words, the borrower is obliged to pay interests on these funds at least for 28 days). Moreover, TAF has been created with the idea that approaching collectively at the auction, banks could avoid the "stigma" associated to DW financing Armantier et al. [2015]. The reason why we include these programs in the analysis is to address the strongest objection linked to these programs: in particular, the fear of moral hazard, because access to a liquidity facility may lead banks to opt for bolder policies with less liquidity self-protection (e.g. lower reserves) and, in the event of a liquidity crisis, to choose to incur debt from the Federal Reserve to avoid default on private debts and preserve creditworthiness. For what concern data on Discount Window, they are published quarterly with two years lag from the first quarter of 2010 (thus our dataset contains data up to March 2014). Particularly, the original data comprise information on 11,448 DW operations conducted from July 2010 to March 2014. Their distribution is provided in Figure A1 (in the Appendix section): among them 8,070 took part in the form of primary credit, 2,836 in the form of seasonal credit and 542 in the form of secondary credit. However, we exclude from the sample credit unions, thrifts and borrower banks which do not belong to bank holding companies (we match banks based on ABA number of commercial banks which are part of BHCs). Provided that 91% of banks asked for funds more than once during each quarter, the dummy variable equals one if the BHC participated in the facility at least once in the quarter; thus we collapse daily data by the creation of a dummy variable equals 1 if the bank participated in the DW program in the quarter of analysis and zero otherwise. Once we exclude multiple accesses in the facility we remain with 6,774 borrower-quarter observations (which become 2,927 when we exclude from the analysis banks which are not part of a bank holding company). TAF was active from December, 12th 2007 to March, 8th 2010 and data were release on December 2010 under the Dodd-Frank Act. Banks participated in this facility 4,214 times. Even in this case banks asked for funds more than once during each quarter: collapsing multiple accesses and excluding banks which are not part of a bank holding company, the dummy variable TAF is equal to 1 in 427 cases. In the first stage of the analysis we do not distinguish among the two facilities and we create the indicator variable *LOLR* equals to one if the bank asked for DW or TAF funds in the quarter

[20]In some cases, the government parties provided capital and agreed to provide certain loss protections and liquidity supports for specific institutions. On November 23, 2008, the U.S. Department of the Treasury, the Federal Reserve, and the FDIC jointly announced that the U.S. government would provide support to Citigroup to contribute to financial market stability. The same happened for Bank of America on January 16, 2009.

of analysis and zero otherwise. Table A4 in the Appendix provides a summary for TAF and DW operations, distinguishing by primary, secondary and seasonal facility.

In order to analyze risk-taking incentives we pay special attention to the sub-sample of banks defined as Systemically Important Financial Institutions (SIFIs). As a regulatory response to the revealed vulnerability of the banking sector in the financial crisis of 2007-08, and attempting to come up with a solution to solve the "too big to fail" interdependence, the Financial Stability Board (jointly with the Basel Committee) has identified factors for assessing whether a financial institution is systemically important: its size, its complexity, its interconnectedness, the lack of readily available substitutes for the financial infrastructure it provides, and its global (cross-jurisdictional) activity. The analysis started in November 2009 and the first official version of the G-SIBs list was published by FSB in November 2011 (and has been marginally updated each year in November). Basel III requires that all identified G-SIBs no later than March 2018, shall operate with a minimum Total Capital Adequacy Ratio comprising: min (8.0%, 8.5%, 9.0%, 9.5%, 10.5%) high quality Tier1 Capital (Common Equity Tier 1 Capital)[21], max 2% Tier2 capital (Subordinated capital), max 1.5% Additional Tier1 capital (Hybrid capital, i.e. Contingent Convertibles aka CoCos). In addition on February 2, 2015 the FSB issued a finalised document that defines a global standard for minimum amounts of Total Loss Absorbency Capacity -TLAC- to be held by G-SIBs.[22] Moreover, in the United States the financial regulator put towards domestic systemically institutions special attention on different dimensions. The Financial Stability Oversight Council (FSOC) does not designate any banks or bank holding companies as systemically important, but the Dodd-Frank Act in the statute imposes heightened supervision standards for specific banks: any bank holding company with a balance sheet larger than 50 billion$ is subject to the Comprehensive Capital Analysis and Review (CCAR) whilst DFAST requirements (Dodd-Frank Act Stress Tests) apply to a broader range of financial companies with total assets over $10 billion.[23] Despite the lack of any official D-SIB designation, banks being subject to the USA Stress Test (CCAR) can be considered to be D-SIBs in the United States.[24] Secondly, All G-SIBs and D-SIBs with headquarters in USA, are also required to submit an updated emergency Resolution Plan each year to the Board of Governors of the Federal Reserve System. Table A5 in the Appendix includes all financial institutions identified as systemically important by the FSB (Global-SIBs) and by the national regulator (the

[21] This requirement towards G-SIBs depends on an indicator-based measure of size, interconnectedness, complexity, non-substitutability and global reach, elevating it to be 1.0% or 1.5% or 2.0% or 2.5% or 3.5% higher, compared to the similar Basel III capital requirement at 7% towards banks not contained in the list.

[22] Moreover, Basel III regulation in addition also introduced a potential counter-cyclical capital buffer, which can be enforced by national authorities on top of the noted Total Capital Adequacy Ratios, with demands of up till 2.5% extra Common Equity Tier1 capital towards all financial institutions (incl. SIBs), during years where the total lending in the specific nation starts to grow faster than the national GDP.

[23] The regulator set the selection criteria, establish hypothetical adverse scenarios and oversee the annual tests. Banks showing difficulty under the stress tests are required to postpone share buybacks, curtail dividend plans and, if necessary, raise additional capital.

[24] The group of banks being stress tested was identical throughout 2009-13, except for MetLife Bank ceasing its banking and mortgage lending activities in 2012 - and therefore subsequently leaving the group of supervised entities. In 2014 the stress test was expanded from 18 to 30 banks, as a result of a phase-in of the provisions of the Board's Dodd-Frank Act stress test rules, only making the additional 12 entities subject to this stress test starting from 2014.

so-called Domestic-SIBs) and we define the dummy variable *SIFIs* equal to 1 in the quarter in which the G-SIBs or D-SIBs *status* is acquired and it stays 1 unless that bank is removed from the list.

Given that for the introduction of Basel III the period of consideration represents a "transition period" because banks have to be fully-compliant with Basel III capital requirements by March 2018 we devote special attention on the sub-sample of banks defined to be under regulatory pressure (*Reg. Pressure*). Particularly, we define banks to be under regulatory pressure when the ratio of Common Equity capital over risk weighted assets (RWA) is below Basel II capital requirement of 8%. In fact, if Basel II regulation (under Pillar I) requires that Total Capital over RWA should be greater or equal than 8%, our index (*Reg. Pressure*) represents the distance from the total capital requirements by common equity; moreover the minimum Basel III requirements will include a 7% Common Equity Tier 1 by January 2019. This dummy variable is equal to 1 if the indicator for bank i at time t has a value below 8%. The distribution along time of the CE/RWA, Total Capital Ratio is provided in Figure 10. Table 2.1, in Section 8, provides the distribution of the dummy variable *Reg. Pressure* along time, showing that for 3832 bank-quarter observations this indicator is equal to 1. The description of the FR-Y9C fields to compute this variable is provided in Table A1 in the Appendix.

Lastly, we focus on banks which have participated into the Treasury's CPP program to investigate the effects of capital shortage. Through the CPP, Treasury purchased preferred stock from qualifying financial institutions aiming at strengthening their capital bases, increasing CPP participants capacity to lend to U.S. businesses and consumers and to support the U.S. economy. Treasury initially committed more than a third of the total TARP funding, $250 billion, to the CPP, which was later reduced to $218 billion in March 2009. At the end of the investment period for the program, Treasury had invested approximately $205 billion under the CPP. Under this voluntary program, Treasury provided capital to 707 financial institutions in 48 states: the first investment was made on October 26th 2008 (to Bank of America) while the final investment was made in December 2009; however, we do not consider Treasury's investments in all 707 because we exclude Small BHCs and commercial banks which are not part of BHCs from the analysis.[25] The indicator variable *CPP banks* is equal to one for the quarter in which the bank under consideration has outstanding capital in the form of CPP preferred stock. The distribution along time for this indicator is provided in Table 2.1 (Section 8).

Variables. In the baseline model we define the increase in assets as the change from previous quarter of the logarithm of Total Assets (including those valued at *fair value*). In the same way, we compute the change in leverage ratio ($\Delta ln(Lev_{i,t})$) as the quarterly log-differenced leverage for bank i at time t (with respect to the previous quarter) and the change in systemic risk, $\Delta ln(SRISK_{i,t})$, as the quarterly log-differenced systemic risk measure for bank i at time t (with respect to the previous quarter). Since both leverage and systemic risk are represented by ratio and percentage respectively, in order to avoid negative-bias due to logarithm of

[25] Respondent to 2015 Survey about use of CPP funds banks declared that they have increased securities purchased (ABS, MBS, etc.), make other investments, increased reserves for non-performing assets, reduced borrowings, increases charge-offs, purchased another financial institution or purchased assets from another financial institution, held as non-leveraged increase to total capital.

percentages between 0 and 1, we adjust the SRISK indicator by shifting of 1 the measure before computing the logarithm; we did not the same for leverage because the minimum value in the sample for leverage is 1 (as reported in the summary statistics).

Concerning the drivers for the increase in leverage, we consider the log-differenced change between two subsequent quarters in the following variables representing short-term debt: issue of commercial paper (*Com.Pap.*), repos (*repo*), repos having as counter-party the Federal Reserve (*FedRepo*), interbank-debt (both borrowed money from other commercial banks in the United States and balances due to subsidiaries) -*Interbank*- and participation into Federal Reserve's liquidity facilities (*LOLR*). When we consider the set of feasible drivers for systemic risk, we add to short-term debt forces, accounting variables which proxy riskiness on the asset side. In particular, we consider the log difference of derivatives in bank's portfolio (*Derivatives*) and the distance from the "traditional" banking activity proxied by the log difference of securities over TA (*Investment b.*); whilst, in order to consider bank-specific riskiness we employ the log-differenced value of the Z-score (*Z-score*). We use the log-difference in *Tier2* to proxy the adjustment towards regulatory capital with Tier2 and the log-differenced value of loans commitments to proxy the riskiness of liquidity draw-up on the assets side. The FRY-9C codes are described in the Appendix (Table 1).

Given that banks' behaviour is affected by changes in economic and financial outlook, or in the degree of certainty about the outlook, we employ a vector of macro variables representing reasons for the change in bank's decisions. The factors capturing the current state of the economy include the change in GDP and inflation, as well as the quarterly change in interest rates (which replicate the shift in the stance of monetary policy). Firstly, in the structural regression we employ a set of interest rates in order to proxy the relative advantage of increasing debt. We consider the average rate on commercial papers (*CP rate*) and the average rate paid on treasury bond (*Treasury rate*). The series are provided from the Federal Reserve Bank of St. Louis (report H15[26]) and they have been transformed in order to take the difference from the previous quarter. Motivated by the findings of Adrian and Shin (2008), according to which banks actively manage their leverage via short-term funds, we hypothesize that short-term interest rates are the keys to explain this relationship. We expect that Fed funds rate determines other relevant short term interest rates (like CP rate, Treasury rates, repo rates and interbank lending rate) through arbitrage in the money market and we predict that low short-term rates are conducive to expanding balance sheets. In order to proxy average productivity and growth we use the current dollar percentage change of GDP at national level (*GDP*) from World Bank and the change in the Consumer Price Index at state level from the US Bureau of Labor Statistics (*Cpi*) in order to proxy inflation. As Finger (1999) shows that the growth rates in the CPI and GDP affect the credit cycle index, symmetrically we hypothesize they might affect the decision to expand liabilities in the short-run (whilst, according to Hofmann [2001], real

[26]Board of Governors of the Federal Reserve System (US), Effective Federal Funds Rate, retrieved from FRED, Federal Reserve Bank of St. Louis; *https://fred.stlouisfed.org/series/FEDFUNDS*.

GDP and interest rates are not sufficient to explain long-run development of credit availability). Concerning the effects on riskiness, De Nicoló et al. (2010) obtain a negative association between two measures of bank risk (risk rating and spreads) and the real GDP growth, consistent with banks turning riskier when the economy is weaker. In order to proxy market-sentiment, we use the log-differenced value of the MSCI US benchmark 10Years government bond index (*Bond Index*) and the total return of S&P500 (*S&P*). Daily return for these indices are provided by Datastream and they have been averaged over the quarter. As another commonly offered reason for the change in bank leverage following the change in risk tolerance, we use quarterly changes in the excess bond premium (*Bond Index*), an indicator of shifts in the effective risk aversion of the financial sector developed recently by Gilchrist and Zakrajsek (2012). Concerning pro-cyclicality of systemic risk, Billio et al. (2012) use S&P500 to capture both contagion effects between financial institutions as well as exposures among all financial institutions to a common factor, e.g., the U.S. equity market; and, Chen et al. (2013) prove that asset returns correlation in the banking sector increase following the increase in the S&P market index and its implied volatility. Moreover, to take into account market volatility we use the log-differenced value of the VIX index for quarter t (*Vix*): as before, daily returns have been averaged over the quarter. The popular measure of risk aversion in the system is the VIX, which is the option implied volatility on the S&P 500 stock price index. In principle, movements in the VIX should also capture fluctuations in economic uncertainty (Bloom, 2009). Accordingly, the quarterly change in the VIX index is included among the set of macro-economic factors that could be driving changes in banks' active management of leverage and systemic risk.

Further, we consider two events in the period under consideration: we use as definition of Crisis, the period from the fourth quarter of 2007 to the second quarter of 2009 as done by the Federal Reserve Bank of St. Louis and the dummy *DFA* which represents the introduction of the Dodd-Frank Act on October 2010. Along with macro-control variables, in the specification of the structural equations estimated via 3SLS, we use bank-specific variables in order to control not only for state-time characteristics which impact all banks but even for heterogeneity across banks. These refer to the log differenced value at time t for bank i of the logarithm of securities pledged as collateral -*Pledged Sec.*- (in the pro-cyclical leverage equation), while in the pro-cyclical SRISK equation we control for the ratio of domestic assets over consolidated assets (Domestic Assets) as provided by the Federal Reserve Statistical Release, and finally for the share of loans to US banks (*Loans US banks*) in order to proxy interconnectedness with the banking system.

2.5 Results

2.5.1 Summary statistics

Table 2.2 provides summary statistics for the main variables considered in the analysis both for the whole sample and for four sub-samples of banks: those that had access to liquidity facilities (*LOLR*), *SIFIs*, banks under regulatory pressure (*Reg. Pressure*) and banks participating in the CPP program (*CPP banks*). In order to avoid mis-leading results due to changes in accounting regulation from local GAAP to IAS/IFRS system and different thresholds of BHCs reporting, we use data starting from the first quarter of 2006 up to the first quarter of 2016 (41 quarters). Data for assets are expressed in million of dollars and we report log-variables and their Δ (log-differenced value with respect to the previous quarter). Number of observations reduced from 41244 to 40529 because in this way we lose the observation in the first period for each bank.

First and second row of each panel show that, on average, SIFI banks are larger than banks participating in Federal Reserve's liquidity and the Treasury's Capital Purchase programs (*LOLR* and *CPP banks* respectively) and both are larger than banks under regulatory pressure. In what concerns the growth rate in assets, the third row of each panel shows that Treasury's participated banks and *SIFIs* are those with the higher growth rate with respect to banks with liquidity shortages and banks under regulatory pressure. Moreover, *LOLR* banks and banks under regulatory pressure are those with high variability in the growth rates and present fat tails towards negative growth rates.

Concerning leverage ratio, the reduction in number of observations is due to the number of listed banks because we consider the sample of banks for which we have information on systemic risk. Banks highly leveraged in our sample are those participating in Federal Reserve's liquidity injection programs and SIFIs, whilst those under regulatory pressure and *CPP banks* are marginally less leveraged. However, all banks in our sub-samples are more leveraged than banks in the control group. Interestingly, when we consider the growth rate of leverage we see that banks in the whole sample and banks under regulatory pressure have a humble growth rate of leverage, but *CPP banks* and banks participating in Federal Reserve's liquidity injections programs have the higher growth rate in leverage; thus, LOLR banks are not only the more leveraged banks in our analysis but also those which are increasing debt even further. Surprisingly, SIFIs have, on average, a deleveraging process with a negative growth rate of leverage.

In what concerns systemic risk, as standard in the literature for percentages, we operated a marginal change adding 1 to the original measure of SRISK (in terms of distribution there are no differences except the shift to the right). This transformation allow us to exclude mis-leading results due to negative values of ln(SRISK) for all values between 0 and 1. Table 2.2 shows that banks under regulatory pressure and SIFIs are those with larger systemic risk with respect to *CPP banks* and banks which participate in the Federal Reserve's liquidity facility.

Systemic risk in all sub-groups is larger than in the whole sample. However, when we consider the growth rate of systemic risk results are quite different: SIFIs are those with the lower growth rate (even smaller than the growth rate of the overall sample), whilst *LOLR* banks have the larger growth rate in systemic risk followed by banks under regulatory pressure and banks participating in the Treasury's Capital Purchase Program.

Table 2.3 reports results from differences in mean across sub-samples. Panel A shows differences among *LOLR* banks and banks did not participate into Federal Reserve's liquidity programs. Results show that, on average, nonetheless *LOLR* banks experienced a lower increase in assets with respect to the control group they had a greater increase in leverage and systemic risk (all differences are statistically significant at 1% level of significance). Moreover, distinguishing among the two liquidity facilities allows us to disentangle the effects of Discount Window from Term Auction Facility programs: differences show that for banks participating in the overnight program (DW), assets growth less than in the control group and leverage decreases with respect to the control group, while for banks participating in the auction-based facility (TAF) assets growth more than in the control group, and they increase leverage more than in the control group. Concerning *SIFIs*, Table 2.3 shows that these banks have a greater increase in leverage with respect to the control group; however, they do not show any difference in the growth rate of systemic risk. Banks under regulatory pressure, *Reg. Pressure*, show a larger growth rate in assets and systemic risk with respect to the control group but a non-statistically significant difference in the growth rate of leverage. Lastly, CPP banks show a decrease in the growth rate of assets and a decrease in leverage with respect to banks which did not participate in the Treasury's CPP program (however, last difference is not statistically significant). Table 2.4 provides results from correlation analysis and confirms the positive and statistically significant correlation among $\Delta ln(TA)$ and $\Delta ln(Lev)$ which is equal to 0.0649 and between $\Delta ln(Lev)$ and $\Delta ln(SRISK)$ which equals 0.326 (significant at all statistical level). This (possibly) lead to correlation between $\Delta ln(TA)$ and $\Delta ln(SRISK)$ of 0.0932 significant at all levels of significance. Distinguishing among sub-samples, correlation analysis in Panel B of Table 2.4, shows that SIFIs are those banks for which the correlation among the growth rate of assets and leverage and the correlation among the growth rate of systemic risk and leverage are the larger.

2.5.2 Empirical analysis

Pro-cyclical leverage. Table 2.5 reports results from the analysis on leverage pro-cyclicality via fixed-effect regressions controlling for year-quarter, bank and Federal Reserve District fixed effects.[27] Particularly, column (1) confirms results from Adrian and Shin (2010): controlling for the logarithm of leverage in the previous period, the increase in assets, when evaluated at fair value, leads to an increase in leverage in the same quarter.

[27] Results from Hausman specification test, available upon request, favour FE in place of RE for specification (1) and (2) of Table 2.5 with a χ^2 statistic of 121.14*** and 176.15*** respectively.

That is, banks are far from being passive and they actively manage their balance sheets increasing leverage during booms and decreasing it during bursts. Columns (2) proves the same result controlling for Federal Reserve district fixed effects: with this specification the overall significance of the regression increases substantially and the degree of pro-cyclicality shift from 14% to 23%; that is, a one percent increase in assets leads to a 23 basis points increase in debt (Adrian and Shin (2010) showed that the increase in debt took place mainly via the increase in short-term liabilities). However, endorsed from evidence in Figure 1, we test if the adjustment in leverage in the short-run is different during the crisis and no-crisis period. Results from column (3) and (4) report that the de-leveraging process during the crisis is more severe than the pro-cyclicality during booms: when fair value of assets decreases by one percent, leverage decreases by almost 43 basis point, while the increase in fair value of assets allows for an increase in leverage of almost 10 bp.

Pro-cyclicality for sub-samples. Evidence from Figures 6(a), 7(a), 8(a), 9(a) leads us to analyze if there are differences among sub-groups of banks in their degree of leverage pro-cyclicality. In particular we test this hypothesis among four groups and results are shown in Table 2.6. Banks participating into Federal Reserve's liquidity programs, column (1), show a more-pronounced pro-cyclical effect of leverage; in fact, their interaction coefficient ($\Delta ln(TA_t) * LOLR$) is positive and statistically significant with respect to the baseline model. This result suggests that these banks, not only ask for funds at the central bank, but they increase their debt even further perhaps benefiting from lower cost of funding after borrowing from these facilities. Column (2) shows results for banks identified by the Financial Stability Board and the Basel Committee on Banking Supervision as "Systemically Important Financial Institutions".[28] These banks, although show a reduction in leverage *per se* -as confirmed by summary statistics-, show pro-cyclicality of leverage and seem to be the category with strongest pro-cyclical behaviour. That is, higher capital requirements which they must be compliant with by 2019, lead them to decrease leverage *per se* but, at the same time, these banks are those which take more advantage when there is an increase in asset value by increasing debt during booms and decreasing it during bursts. One of the reasons for this evidence could be associated to the trade-off of their *status*: on one hand, they have to be compliant with higher capital requirements, on the other hand, they benefit from the TBTF *status* which increases their creditworthiness and allows them to benefit from cheaper sources of funding. Column (3) tests our prediction for the set of banks considered under regulatory pressure: this group identifies banks with a "$Equity/RWA$" ratio below 8%. Consistently with economic intuition, banks that have to be compliant with tougher capital regulation not only show that leverage is not pro-cyclical but show that the interaction coefficient is negative and larger than that in the baseline group ($\Delta ln(TA_t) * Reg.Pressure$). Intuitively, during booms they use proceeds from the increase in equity in order to deleverage with a negative slope overall. Results from column (4) report coefficients for banks which have participated into Treasury's Capital Purchase

[28] As stated before we do not distinguish from Domestic and Global Sibs (D-Sibs and G-Sibs).

Program. Interestingly, CPP banks show a negative coefficient for the interaction term however, the net effect is still positive. This evidence suggests that banks increasing their share-offering having as counter-party the Treasury, operate during booms via deleveraging. The net effect appears to be still positive even if very mild with respect to the baseline group.

Motivated by the evidence that bank's leverage management might be different along time, Table 2.7 (Panel A and B) reports the same analysis distinguishing two different periods: crisis and no-crisis. Interestingly, for the group of $LOLR$ banks the coefficient associated to pro-cyclicality of assets is positive and in line with what found during the overall period; however, the same group shows that they did not deleverage during the crisis: when asset value fell down, they did not decrease leverage resulting in a non-statistically significant coefficient for $\Delta ln(TA_t) * LOLR$. In fact, these banks increased their leverage participating into Federal Reserve's liquidity facilities during the crisis. Concerning SIFIs and banks under regulatory pressure there are no differences among the crisis and no-crisis period except in the magnitude, which plays a significant role. If during booms SIFIs increase their leverage by 35 basis points following an increase of one percentage point in assets value, during the crisis they operate strongly via deleveraging reducing by almost 5% their leverage when assets value decrease by 1%; analogous story happened for banks under regulatory pressure (*Reg. Pressure*): they operate with a counter-cyclical leverage during booms -reducing debt following an increase in assets value- and increasing debt during the crisis when assets value decrease. However, due to the difficulties in raising equity during the crisis their degree of counter-cyclicality is stronger during bursts. Lastly, *CPP banks* show a negative coefficient associated to the interaction variable $\Delta ln(TA_t) * CPP$ although the net effect is mild but still positive during the boom; during the crisis period CPP banks show a counter-cyclical leverage increasing their debt more than the increase in equity when assets value decreases. The fact that banks tend to increase debt during downturns could be explained by standard corporate finance theories like debt overhang and pecking order theory.

In order to check for possible drivers of previous evidence we perform a fixed effects regression substituting the growth rate of assets with acceptable candidates for the increase in short-term debt. Even if previous literature suggests that banks actively manage their liability side via repos (as the best candidate for short-term debt), our hypothesis is that it is not always the case. In fact, Table 2.8, shows that for the whole group in our sample, column (1), the increase in leverage is mainly due to the increase in interbank funding with a positive coefficient of 0.1976; Columns (2), (3), (4) and (5) show that this evidence is not validated for all sub-groups under analysis. Particularly in column (2), banks which took part in the Federal Reserve's liquidity injection programs, that is banks that borrow short-term fundings from Discount Window and Term Auction Facility, show an increase in repo funding having as counter-party the Federal Reserve, a heavier reduction in repos as funding source and, more than others, they rely on interbank fundings. This evidence is at odds with what has been shown from Adrian and Shin (2010): our analysis confirms that banks increase their short-term financing but repo is not the main source (at least for this group of banks). Column (3) provides results for the group of SIFI banks. For this sub-sample results show that the adjustment in leverage happens via traditional short-term debt (repos) which goes with the participation into Federal Reserve's liquidity injection programs and both act as substitutes of commercial paper (for which SIFIs show a deleveraging process). Results from column (4) report the coefficients for the group of banks under regulatory pressure (*Reg. Pressure*): in line with results from previous regressions, these banks do not increase debt in the short-run; at the same time, the fact that none of these coefficients report a negative and statistically significant contributing factor to the decrease in debt means that the deleveraging process happened substantially via an increase in equity. Banks participating into the Treasury's CPP program, coherently with results from Table 2.6 and 2.7 show mixed results: on one hand, they increase their solidity from the equity injections following CPP preferred stocks but, on the other hand, evidence shows mixed directions on short-term debt. Column (5) shows positive coefficients associated with an increase in interbank debt and repos having as counter-party the Federal Reserve and a deleveraging process in commercial paper. This evidence does not allow a unique prediction for CPP banks where the prevailing effect will depend on the relative magnitude of these countervailing forces.

Pro-cyclical systemic risk. In this section we test if periods of booms, via the increase in assets, are associated with a shift in the risk appetite of BHCs measured by the change in systemic risk. In Table 2.9, the baseline model, column (1) shows that when assets increase, as expected, banks become more "systemic" increasing their systemic risk. However, distinguishing our sample by sub-groups contrasting results appear. In particular, banks participating into Federal Reserve's liquidity injection programs, column (2), show that systemic risk increases during booms; these results are in line with evidence in Table 2.8: banks participating in LOLR programs, not only increase their short-term debt with Discount Window or Term Auction Facility, but also increase interbank debt and repos with the Federal Reserve. When the increase in leverage happens via the interbank market, this more likely will foresee the increase in their systemic riskiness. Interestingly, column (3) shows the effects of the increase in assets for SIFI banks: they exhibit a pro-cyclical behaviour with respect to systemic risk; that is, an increase in assets value is associated to a positive growth of systemic risk in the same quarter validating the hypothesis that even if banks increase their capital in order to be compliant with tougher capital requirements, the increase in leverage, its composition, and in the interlinkages among banks have a positive effect on the growth rate of systemic risk. This evidence is in line with results from Table 2.8 (column (3)) showing that SIFIs increased repos and their indebtedness with the Federal Reserve from LOLR programs. Columns (4) and (5) show that systemic risk is counter-cyclical for banks under regulatory pressure and for banks which have participated into Capital Purchase Program even if their net effect is different. That is, taking into account both the interaction variable and the baseline group we notice that banks under regulatory pressure ($\Delta ln(TA_t) * Reg.Pressure$) react from an increase in the fair value of assets with a decrease in the growth rate of systemic risk or, in other words, in order to be compliant with more stringent capital requirement they neither increase leverage during booms nor their degree of systemic risk. Whilst, for banks participating into CPP program the interaction coefficient is still negative but does not compensate the one in the baseline model.

At odds with results from leverage pro-cyclicality, Table 2.10 shows differences among the crisis and no-crisis period in the degree of systemic risk pro-cyclicality for the same sub-samples of banks. Panel A shows that, during booms, LOLR banks do not increase their systemic risk more than in the baseline group following the increase in assets value; however Panel B shows that they reduce their interlinkages more than the baseline group during the crisis. The opposite happens for SIFI banks, for which the increase in systemic risk following the increase in assets is confirmed during the boom period, while during the crisis period no statistically significant differences emerge with respect to the baseline group. That is, SIFIs do not reduce their interconnectedness when assets value decreases. For the sub-sample of banks under regulatory pressure Table 2.10 shows in Panel A that these banks do not increase their systemic risk during bubbles, however Panel B shows that during burst they reduce systemic risk following the increase in assets value. Banks participating into the Treasury's CPP program show that systemic risk increases when assets value increase during boom (Panel A), whilst their systemic risk contribution increases also when assets value fall down (Panel B). In Table 2.11 we study the effects of systemic risk pro-cyclicality on two sub-sample of banks: those with a leverage ratio below 12.5% and above 12.5%. Following our prediction in Equation (9), the idea is to test if there are differences among high leveraged and low leveraged banks because under a threshold of 12.5% banks have room for a pro-cyclical leverage without impact systemic risk. This is so because the underlying, in the short-put option (the inverse of quasi-market leverage), does not reach the strike price implied by Basel capital requirements. Results exhibit that for all banks in our sub-samples results of previous tables are confirmed in Table 2.11 as long as the leverage ratio is greater than 12.5%. Thus, even if the degree of leverage pro-cyclicality and systemic risk pro-cyclicality is different across groups they have a unique behaviour in what concern targeting systemic risk.

Table 2.12 analyses a set of feasible drivers for systemic risk pro-cyclicality. Column (1) shows that systemic risk increases following the reduction in Tier2, whilst it increases when bank-specific riskiness increases -*Z-score*-. Moreover, pro-cyclicality of systemic risk for *LOLR* banks goes on the assets side riskiness motivated by the increase in derivatives and in their liquidity exposure via loans commitments (*Loans Comm.*). Column (2) shows for *SIFIs* that systemic risk increases when increase short term debt in the form of *repo*, when they meet capital requirements with Tier2 instruments and when they are exposed to liquidity shortages on the asset-side. Both LOLR and banks under regulatory pressure increase systemic riskiness following a reduction in securities (*Investment b.*), even if their motivations might be different: for LOLR banks could be associated to a shift from trading securities to collateralised securities, while for banks under regulatory pressure could be explained by the increase in fire-sales of assets. It is important to notice that banks under regulatory pressure increase their systemic riskiness following an increase in their business *Z-score*. As before, for banks have participated in the Treasury's CPP programs, column (4), no clear results come to light both as liability and asset components. **Structural model.** Previous results might be mainly driven by endogeneity of leverage, to its pro-cyclical behaviour and to the interplay with specific drivers related to systemic risk. Thus, we perform structural equation via three stages least squares (3SLS) in order to take into account this source of endogeneity. As before, when assets value increase we should expect a negative effect in quasi-market value of leverage, leading to a decrease in systemic risk. However, the total effect on systemic risk, is due to the interplay of different factors. We test our previous hypothesis in Table 2.13 and 2.14 where the reference group is described at the top of each column. For each sub-sample, controlling for the same set of exogenous variables, we provide results for two different system of equation replacing $\Delta ln(TA_t)$ with $\Delta ln(Lev_t)$ in systemic risk equation. Table 2.13 provides results for banks which have participated into the Federal Reserve's liquidity facilities distinguishing among Term Auction Facility and Discount Window. For all of the them the baseline model shows a pro-cyclical behaviour of leverage, that is, leverage increases following the increase in assets value. However, the contrasting evidence of the mediated effect of leverage on systemic risk for LOLR interaction term lead us to further split the sample among the two facilities. Particularly, columns (3) and (4) show that leverage is pro-cyclical for banks participating into the auction-based liquidity facility, whilst for banks which rely on Discount Window leverage is counter-cyclical meaning that when assets value increases they reduce short-term debt. Moreover, Panel 2 shows that pro-cyclicality of systemic risk is confirmed: the increase in assets value (as well the increase in leverage) lead "*per se*" to an increase in systemic risk, nonetheless differences among the two groups persist. For banks participating in the Term Auction Facility program the degree of systemic risk pro-cyclicality due to the increase in assets value is larger than for banks participating into the Discount Window program; however, the mediated effect of leverage shows that for TAF banks an increase in leverage leads to a smaller increase in systemic risk than the control group; while, for DW banks an increase in leverage leads to a larger increase in systemic risk with respect to the baseline model. Last evidence is in line with the perceived "stigma" associated to banks which borrow from the DW program (Brunnermeier, 2009). Armantier et al. (2015) proved how banks participating in the Discount Window are perceived as financial constrained by market participants with negative return on the market. The exogenous variables in the leverage equation confirm expected effects: for example, banks are reluctant to increase leverage when rate on commercial paper is sufficiently high (increasing their cost of debt), while the higher rate on Treasury securities confirms assets expansion via leverage during boom period. Systemic risk equation shows that periods of greater vulnerability in the market are associated to higher growth rate in systemic risk -as proved by the positive coefficient of Vix-, that systemic risk increases for banks borrowing from Discount Window which lend to other US banks and that systemic risk increases when returns on the market are particularly high (as confirmed by the positive coefficient of $S\&P$). Moreover, results show the reduction in systemic risk following the introduction of the Dodd-Frank Act and that a larger share of domestic assets is not related to a larger systemic risk, but that systemic risk grows more for banks exposed in the international markets (contrary to international diversification theory).

Concerning SIFI banks, Table 2.14 shows that when assets value increases, leverage is pro-cyclical confirming previous results; however, structural equation reveals contrasting results with Table 2.9: provided that the increase in leverage and in assets value both lead to an increase in systemic risk, the group of SIFIs does not show any significant difference with respect to the control group with reference to the increase in assets. On the other hand, the larger pro-cyclicality of systemic risk for this group of banks is evidenced by the mediation effect: when leverage increases, systemic risk increases more than in the baseline group. Columns (3) and (4), provide results for regulatory constrained banks: as shown in previous tables, leverage for this group of banks is counter-cyclical; that is, they react to an increase in assets with a reduction in leverage. Moreover, when we disentangle the direct effect of the increase in assets and the mediated effect of the increase in leverage on pro-cyclicality of systemic risk, evidence shows contrasting results. In particular, following an increase in assets banks under regulatory pressure increase their systemic riskiness more than in the control group; while, following an increase in leverage, systemic risk for this sub-sample of banks increases less than in the baseline group. Finally, for the sample of bank participating in the Treasury's CPP program, columns (5) and (6) confirm a counter-cyclical leverage with respect to the baseline group. For what concern pro-cyclicality of systemic risk an increase in assets lead to a reduction in systemic risk with respect to the control group, while the increase in leverage amplifies the increase in systemic risk with respect to the baseline model.

2.5.3 Interaction among programs

As we pointed out before, during the financial crisis to maintain confidence in the financial system and to ensure that banks continued to supply loans and avoid panic in the economy, Federal Reserve and Treasury officials became convinced that a systematic approach to face the financial system solvency risk was needed. Beyond expanding Fed lending programs and bailouts in response to some individual failures, for which they evaluate pertinence case by case, they have created specific capital injections and liquidity programs: among them the Treasury's Capital Purchase Program, the Federal Reserve's Term Auction Facility and renewed the Discount Window lending facility.

Moreover, in November 2013, the Treasury estimated the eventual nominal gains on all CPP investments declaring it would be roughly $16 billion (U.S. Government Accountability Office, 2014) and that the program had succeeded in improving banks capital levels, thereby enhancing their ability to borrow and to lend: which are the consequences of the increased "borrowing ability"? In this section we analyze whether the reliance on both liquidity and capital injection programs might have unforeseen consequences on systemic riskiness. From the bank's management point of view, the implicit moral hazard which arises from the presence of these facilities, might result in more risk taking in the future. While, from the market point of view, in presence of expectations of government support (bailouts), market prices may inaccurately reflect systemic risk. In particular, given the goal of each liquidity/capital program we considered, we investigate whether the joint-participation in both programs lead to reverse effects. Lender of Last Resort programs from the Federal Reserve were especially addressed to banks facing liquidity shortages in the short-run, whilst the Treasury advocates CPP funds for all non-financially stable banks in order to restore their capital levels and improve lending ability. In more detail, we conduct previous analysis on three groups of banks. Firstly, we consider banks which both participated into the Federal Reserve's liquidity facility and issued preferred stock bought from the Treasury. On 707 institutions which participated into the CPP program in 2009, we have information on 43 of them which borrowed money from the Federal Reserve as well. Collateralised lending to banks relies upon the use of relatively high-quality assets to make government loans less risky to the central bank or taxpayers. This form of assistance can be effective in resolving pure liquidity problems (where banks lack cash but their problems do not reflect a significant increase in their risk of insolvency). Collateralised lending does not work, however, when bank illiquidity is a symptom of substantially increased default risk of the bank (Calomiris and Khan, 2015). In such circumstances, the use of collateralised lending can actually exacerbate the liquidity problems of a bank by effectively subordinating the banks depositors to the central bank or government lender (as depositors' claims become effectively junior to the new lender and are backed by relatively risky assets). Under such circumstances, a collateralised loan that raises the riskiness of deposits might even cause a depositor run rather than prevent one. Secondly, we ask whether CPP funds are really suited for all banks and we investigate if, for high-leveraged banks (especially those with fixed income bond), the participation to CPP program might exacerbate the "debt-overhang" hypothesis (Calomiris and Khan, 2015). In fact, when banks are close to the failure, managers and shareholders prefer to gamble for their rebirth investing in high-return/high-volatility projects. CPP arises in the form of preferred stock purchases. Any purchases of securities (such as preferred stock) had to be accompanied by the granting of warrants (which allow future purchases of stock from the bank at a pre-established price) to ensure that taxpayers shared in the upside potential of recipient institutions. The presence of the Treasury, in the form of preferred-stock investor, push away existing shareholders from the bank's residual claim leading them to further ask for riskiness behaviour. With these respect, we conduct previous analysis on those banks which participated in the CPP program and were highly leveraged (with a Tier1 Capital ratio below the median). Lastly, we investigate how our results change for banks which have participated in the CPP program in 2009 and did not buy-back preferred shares in the same year. Participants that did not exit CPP early were relatively weak, had larger loan losses, and increasingly displayed problems in paying dividends and maintaining profitability (U.S. Government Accountability Office, 2013b). Are there any effects in terms of pro-cyclicality of systemic risk? Table 2.15 reports in column (1) and (2) results from structural equation for the group of banks which jointly participated in the Treasury's Capital Purchase Program and in the Federal Reserve's Term Auction Facility. Differently from our prediction, evidence shows that both programs reached jointly their scope: that is leverage is counter-cyclical (meaning that the increase in capital more than compensate for the increase in debt), whilst both the percentage change in assets and the mediated effect of leverage show counter-cyclical systemic risk with respect to the control group. Columns (3) and (4) exhibit results for banks participating in the CPP program with a Tier1 Capital Ratio below the median (among these banks). Evidence show that they do not manage actively leverage increasing debt when assets value increases but decreasing it; however, when low capitalised banks further increase debt, systemic risk reacts in a pro-cyclical way with respect to the control group. Coherently with gambling incentives for risky assets (Acharya and Steffen, 2015), when assets value increases systemic risk is pro-cyclical with respect to the control group. Lastly, banks which participated in the Treasury's Capital Purchase Program in 2009 and did not pay-back preferred shares in the same year show no differences in procyclicality of leverage with respect to the control group (in line with the increase in capital) and no pro-cyclical systemic risk due to the increase in assets value. Furthermore, when these banks increase leverage the mediated effect on riskiness shows a pro-cyclical systemic risk.

2.6 Concluding remarks

The new capital regulatory framework -Basel III-, the increase in information disclosure required by the Dodd-Frank Act and the extra capital requirements for SIFIs all imply the need to investigate the pro-cyclicality of leverage beyond what done by Adrian and Shin (2010). Their empirical findings show that banks' balance sheets expand by borrowing more during booms and contract during bursts (so-called leverage is pro-cyclical). Using quarterly data from a sample of 1635 US Bank Holding Companies (BHCs) from 2006 to 2016, our baseline model confirms that leverage is pro-cyclical. However, some differences come to light along the different groups of banks characterized by capital and liquidity shortage. Leverage is pro-cyclical for the group of banks participating into the Federal Reserve's liquidity injections program and for SIFIs, whilst, it is counter-cyclical for banks under regulatory pressure (those with a ratio of equity over RWA below 8%) and for those banks participating in the Treasury's CPP program. Results are confirmed when we discriminate among crisis and no-crisis periods for all sub-samples of banks (expect for CPP banks which show a pro-cyclical leverage during the crisis).

Besides, the recent financial crisis led regulators to call for more stringent capital requirements for TBTF banks, to monitor the degree of interconnection in the financial markets and to purposely, monitor bank's capital adequacy via stress test by the fear that the distress of a financial institution impairs the functioning of the financial system. As long as the increase in the value of assets makes banks larger and more interconnected (i.e. via an increase in the interbank debt) and banks do not completely internalise the costs of their fragilities, it is worthwhile studying implications of leverage procyclicality on systemic risk. Thus, on the same sub-samples of banks, we study the effects of the increase in assets value on systemic risk pro-cyclicality. Our results reveal that the degree of systemic risk pro-cyclicality increases for banks that rely on Federal Reserve's liquidity facilities and for SIFIs; whilst systemic risk is counter-cyclical for banks under regulatory pressure and, for banks participating into the Treasury's CPP program systemic risk is still pro-cyclical but lower than the control group.

However, we cannot neglect the fact that under general economic theory both the increase in assets and the increase in leverage positively affect the increase in systemic risk and running two separate regressions would lead to a mis-specified model. Thus, to tackle endogeneity of the increase in leverage, we perform a structural equation model via 3SLS. Controlling for a set of exogenous variables, our structural equation model allows us to examine the effect of an increase in the fair value of assets on the change in systemic risk disentangling the effects of the increase in leverage and in assets. Our results show again that SRISK is pro-cyclical: the links among banks (in terms of their interconnectedness) increase during booms and decrease during bursts. Moreover, structural regression leads to an economically and statistically large difference between banks participating in the Federal Reserve's liquidity programs or banks participating into Treasury's CPP program. In particular leverage is pro-cyclical for banks which have participated in the Term Auction Facility while it is counter-cyclical for banks which have participated in the Discount Window. However, for both type of borrowers systemic risk increases following the increase in assets with respect to the baseline group, while for auction-based borrowers the increase in leverage leads to a smaller increase in systemic risk with respect to the control group. Discount Window borrowers show opposite results: the sensitivity of the increase in systemic risk following the increase in leverage is larger than in the control group, coherently with evidence on "stigma" for these borrowers. Structural equations confirm that leverage is counter-cyclical for banks under regulatory pressure and banks participating in the Treasury's CPP program, but evidence on systemic risk pro-cyclicality for these sub-samples of banks show contrasting results. CPP banks show a lower degree of systemic risk pro-cyclicality with respect to the control group, while regulatory constrained bank evidence a larger increase in systemic risk following the increase in total assets. Finally, differences come to light for SIFIs: they confirm leverage pro-cyclicality in the structural equation, however when we take into account endogeneity of leverage, results do not show systemic risk pro-cyclicality for this group of banks.

The results of this work might have implications in terms of regulatory capital requirements, state-aid in the form of capital, liquidity provisions by the Federal Reserve and mandatory disclosure of information. That is, the analysis shows that the banks that get into debt through the Term Auction Facility show leverage pro-cyclicality but have no implications in terms of pro-cyclical systemic risk; while banks which borrow through the Discount Window are those that suffer the most in terms of systemic risk; as demonstrated by Armantier et el. (2015), Discount Window borrowers suffer negative reactions on the market as a result of participating in this facility with negative implications in terms of SRISK. In this way, the liquidity provision from the US Central bank and the disclosure of Discount Window borrowers are two opposing forces which go against each other for the financial wealth of the bank. On the contrary, as regards the effects on systemic risk pro-cyclicality, the extra capital requirements for SIFIs or their compliance to the Supervisory Capital Assessment Program demonstrate to achieve the objectives of the regulators. Although TBTF banks confirm pro-cyclical leverage, there are no effects on pro-cyclicality of systemic risk. Finally, for what concerns implications in terms of financial fragility and interconnectedness (as a result of the increase in the value of assets), our results prove that the regulator's attention should be directed to well-capitalised banks and not to those under regulatory pressure.

2.7 Graphs and Figures

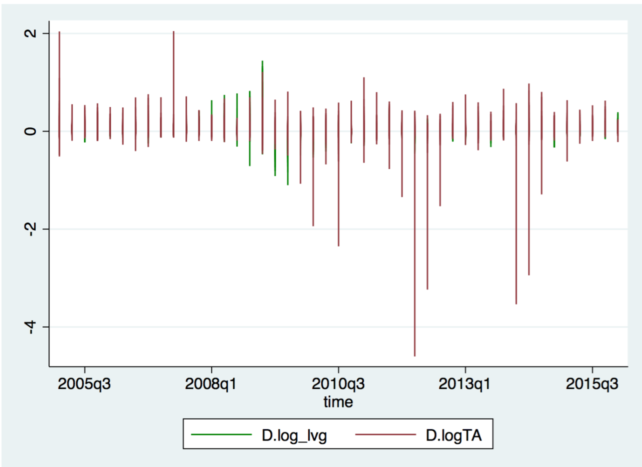


Figure 2.1: Changes in assets and leverage over time

This graph reports the co-movements of the increase in leverage and the increase in asset values along the quarters considered in the analysis, and without distinguishing by categories of banks. The green spikes represent the first difference in the logarithm of leverage with respect to the previous quarter, whilst the red spikes represent the first-difference of the logarithm of total assets with respect to the previous quarter.

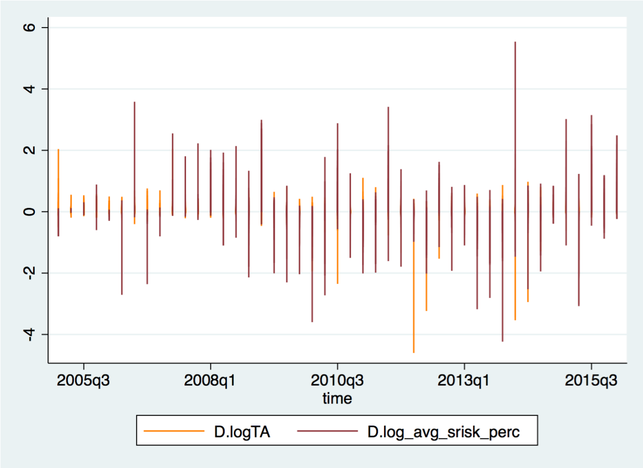


Figure 2.2: Changes in assets and SRISK over time

This graph reports the co-movements of the increase in systemic risk and the increase in asset values along the quarters considered in the analysis, and without distinguishing by categories of banks. The orange spikes represent the first difference in the logarithm of total assets with respect to the previous quarter, whilst the red spikes represent the first-difference of the logarithm of systemic risk with respect to the previous quarter. In order to avoid negative values due to the logarithm of systemic risk between 0 and 1 we normalised it by shifting the entire distribution by 1 to the right.

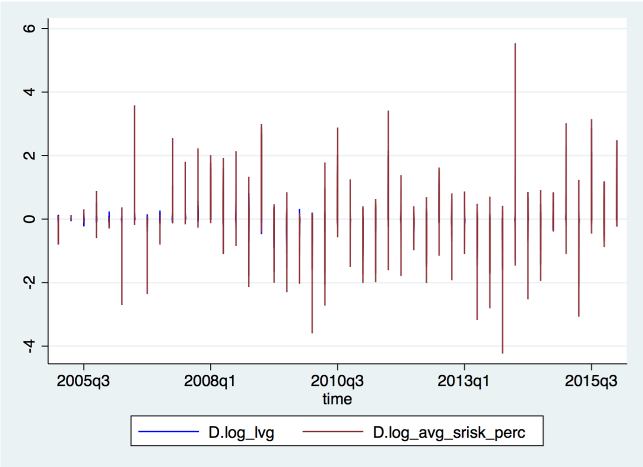


Figure 2.3: Changes in leverage and SRISK over time

This graph reports the co-movements of the increase in systemic risk and the increase in leverage along the quarters considered in the analysis, and without distinguishing by categories of banks. The blue spikes represent the first difference in the logarithm of leverage with respect to the previous quarter, whilst the red spikes represent the first-difference of the logarithm of systemic risk with respect to the previous quarter. In order to avoid negative values due to the logarithm of systemic risk between 0 and 1 we normalised it by shifting the entire distribution by 1 to the right.

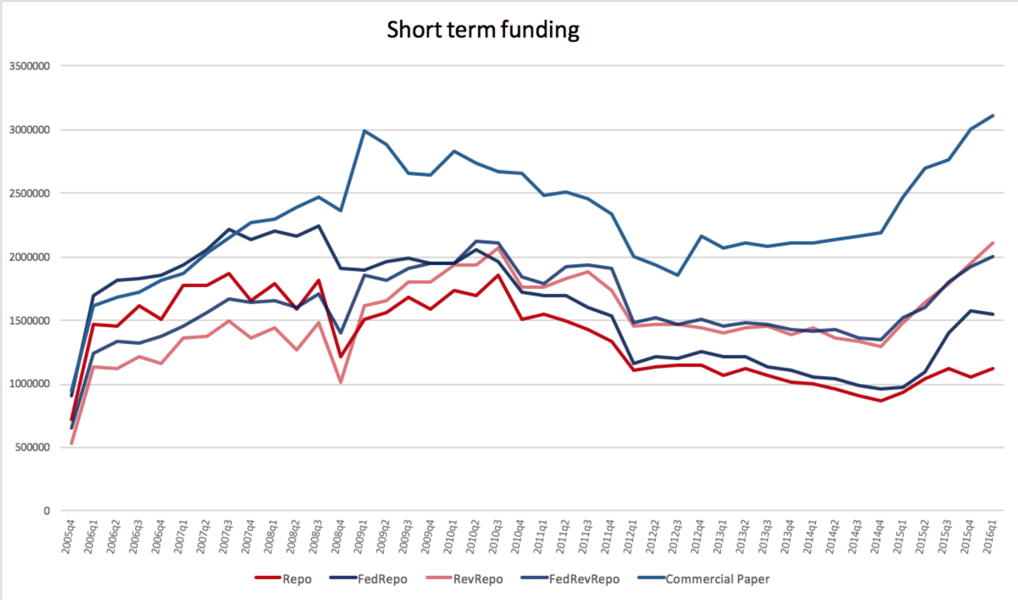


Figure 2.4: Short-term financing

This graph shows the path of short-term funds for the banks considered in the analysis. Values represent averages in thousand of dollars for the banks in the sample and without distinguishing among categories of banks. As short-term funds we consider repurchase agreements, repurchase agreements with the Federal Reserve, and commercial paper. This graph also reports the path for reverse repo and reverse repo with the Federal Reserve although in the regression analysis the net values are included.

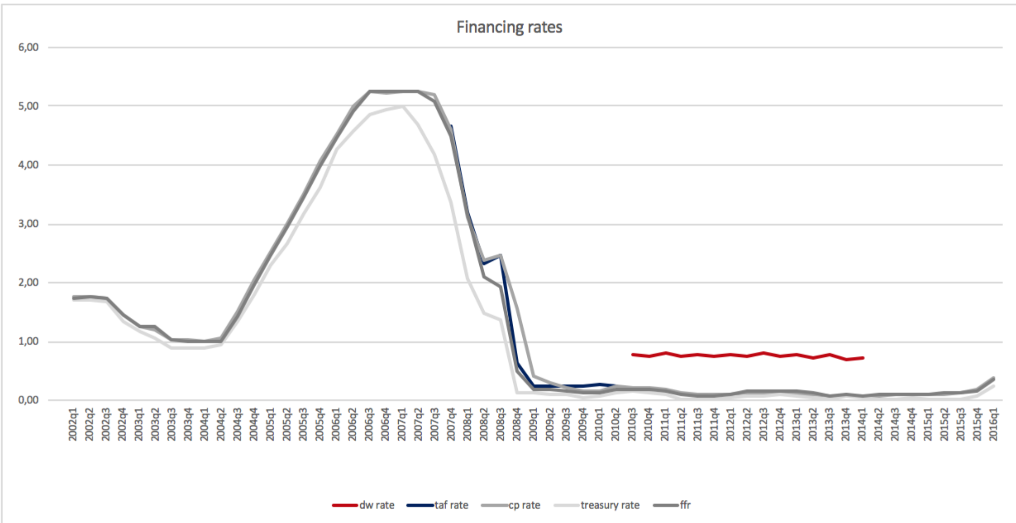
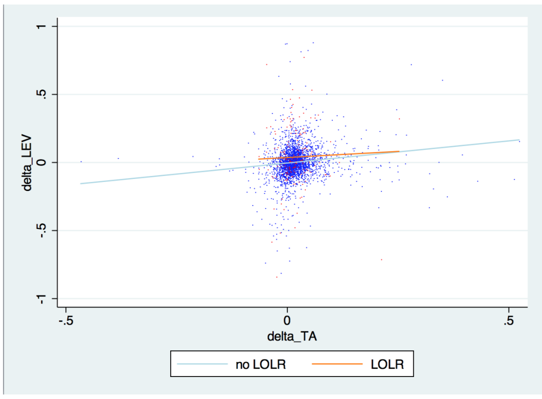
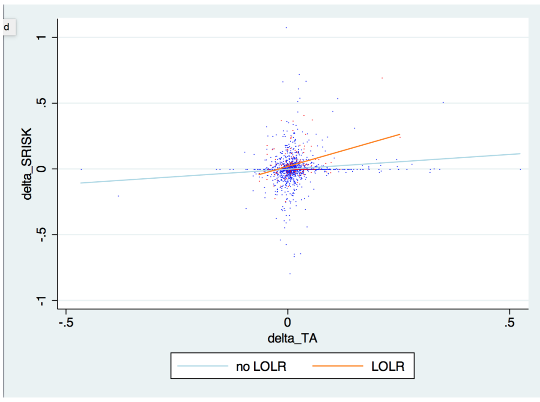


Figure 2.5: Short-term financing rates

This graph shows the path of short-term financing rates for the banks considered in the analysis. Values on the left-scale represent percentages. The historical series for the Federal Fund rate is reported because it represents the pivotal rate for all the others short-term rates in the market and because it is the way by which the Central Bank implements the monetary policy. The Treasury rate serie is provided by the Federal Reserve Bank of St. Louis as the rate on commercial paper in order to proxy the average price to support funding needs through commercial paper (3-Month AA Financial Commercial Paper Rate). We report for the operating period of the Term Auction Facility (2007-2010) and for the period of the Discount Window (2010-2014) on which we have information, the average interest rates paid on these facilities.



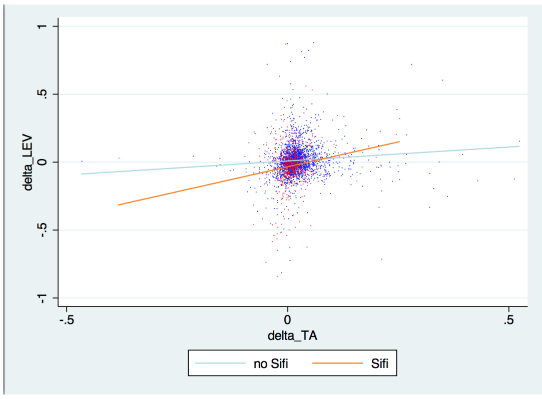
(a) Pro-cyclical leverage



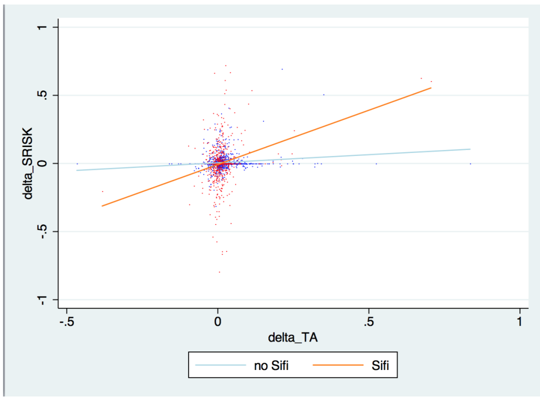
(b) Pro-cyclical srisk

Figure 2.6: Banks participating in LOLR facilities

These graphs show, through a scatter, the degree of pro-cyclicality of leverage (a) and systemic risk (b) as a function of the change in the logarithm of market value of assets with respect to the previous quarter. The group of banks considered are those participating in the liquidity facilities activated by the Federal Reserve (Discount Window and Term Auction Facility).



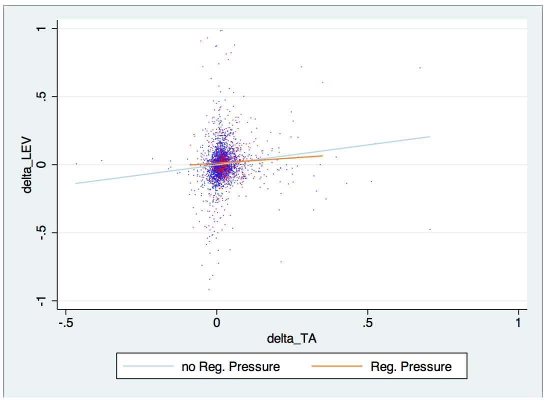
(a) Pro-cyclical leverage



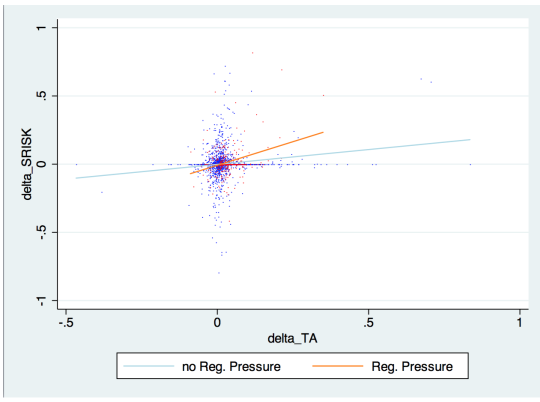
(b) Pro-cyclical srisk

Figure 2.7: Banks identified as Sifi

These graphs show, through a scatter, the degree of pro-cyclicality of leverage (a) and systemic risk (b) as a function of the change in the logarithm of market value of assets with respect to the previous quarter. The group of banks considered are those identified by the Financial Stability Board and the Basel Committee on Banking and Supervision as Systemically Important Financial Institutions.



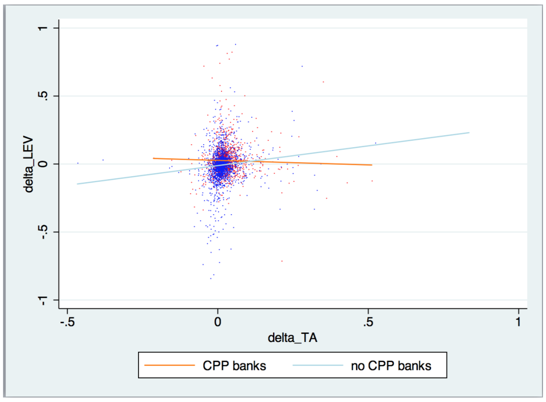
(a) Pro-cyclical leverage



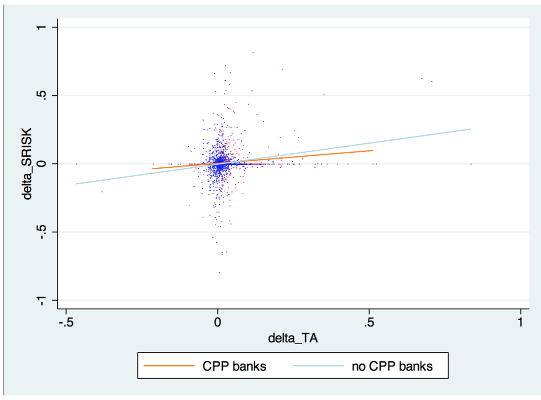
(b) Pro-cyclical srisk

Figure 2.8: Banks under Regulatory Pressure

These graphs show, through a scatter, the degree of pro-cyclicality of leverage (a) and systemic risk (b) as a function of the change in the logarithm of market value of assets with respect to the previous quarter. The group of banks considered are those defined as under *Regulatory Pressure* according to a ratio of common equity over risk weighted assets below 8%.



(a) Pro-cyclical leverage



(b) Pro-cyclical srisk

Figure 2.9: Banks participating in the Treasury's Capital Purchase Program

These graphs show, through a scatter, the degree of pro-cyclicality of leverage (a) and systemic risk (b) as a function of the change in the logarithm of market value of assets with respect to the previous quarter. The group of banks considered are those which have participated in the Capital Purchase Program activated by the US Treasury.

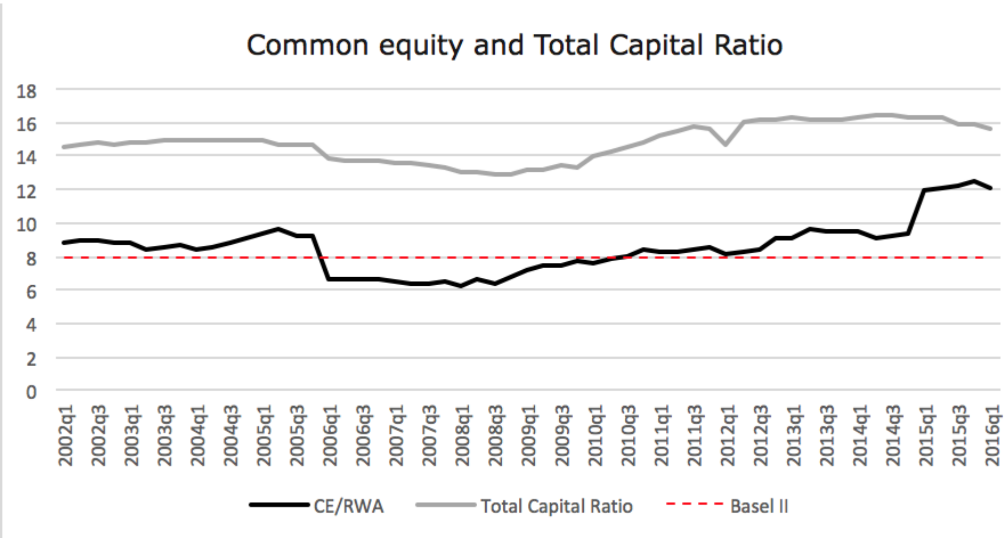


Figure 2.10: Common Equity ratio and Total Capital Ratio (BS RWA)

This graph shows the average Common Equity Ratio and Total Capital Ratio for the sample of banks considered in our analysis. The red dashed line indicates the Basel II threshold (8%), whilst the Total Capital Ratio (grey line) adds extra-capital considered in the Tier 1 and Common Equity capital over Risk Weighted Assets.

2.8 Tables

Table 2.1: Sub-samples of banks

Year	**LOLR**	**Sifi**	**Reg. Press**	**CPP banks**	**LOLR & Sifi**	**LOLR & REG**	**LOLR & CPP**	**Sifi & REG**	**Sifi & CPP**	**REG & CPP**
2006			481							
2007	5		426			2				
2008	71		497			14				
2009	130	18	525	291	13	22	43	5	7	95
2010	336	18	471	248	2	52	43	4	9	97
2011	571	18	390	220	4	73	46	5	4	81
2012	584	18	325	159	7	57	30	3	4	60
2013	681	19	300	108	9	75	25	2	2	47
2014	100	31	258	61	2	14	6	1	1	26
2015		31	91	20				1	1	2
2016		31	68	13						2
Tot.	2478	184	3832	1120	37	309	193	21	28	410

This table reports the distribution by year for different categories of banks. First column reports banks had access to LOLR facilities, the second column reports banks belonging to the group of Systemically Important Financial Institutions, the third column reports regulatory constrained banks (*Reg. Pressure*) and the fourth column shows the distribution for banks participating into the Treasury's CPP program. Other columns report their intersections.

Table 2.2: Summary statistics

Variable	Obs	Mean	Std.	Min	Max
		All			
Total Assets	41244	1.60E+07	1.01E+08	376	2.55E+09
ln(TA)	41244	14.221	1.448	5.930	21.659
$\Delta ln(TA)$	40592	.0128	.068	-4.602	2.048
Lev.	3361	7.959	6.825	1.020	100.000
ln(Lev.)	3361	1.887	.598	.020	4.605
$\Delta ln(Lev.)$	2995	.007	.146	-1.225	1.444
SRISK	3361	1.716	2.558	1.000	21.867
ln(SRISK)	3361	.223	.583	.000	3.085
$\Delta ln(SRISK)$	2995	.004	.111	-1.703	1.877
		LOLR			
Total Assets	1861	3.40E+07	2.02E+08	160627	2.52E+09
ln(TA)	1861	14.492	1.656	11.987	21.647
$\Delta ln(TA)$	1843	.006	.087	-3.235	.705
Lev.	195	13.345	13.520	1.130	100.000
ln(Lev.)	195	2.273	.813	.122	4.605
$\Delta ln(Lev.)$	187	.063	.291	-.915	1.331
SRISK	195	2.631	3.667	1.000	17.810
ln(SRISK)	195	.486	.813	.000	2.880
$\Delta ln(SRISK)$	187	.042	.124	-.244	.694
		SIFIs			
Total Assets	757	4.12E+08	5.71E+08	4.20E+07	2.52E+09
ln(TA)	757	19.180	1.060	17.553	21.647
$\Delta ln(TA)$	751	.010	.054	-.383	.705
Lev.	614	10.838	8.267	2.363	100.000
ln(Lev.)	614	2.240	.496	.860	4.605
$\Delta ln(Lev.)$	610	-.018	.201	-1.101	1.444
SRISK	614	3.136	4.037	1.000	19.957
ln(SRISK)	614	.646	.869	.000	2.994
$\Delta ln(SRISK)$	610	.001	.167	-1.232	1.077
		Reg. Pressure			
Total Assets	12265	1.28e+07	1.15e+08	4888	2.30E+09
ln(TA)	12265	13.945	1.163	8.495	21.557
$\Delta ln(TA)$	12052	.008	.086	-4.602	.9771
Lev.	367	10.574	9.671	1.766	100.000
ln(Lev.)	367	2.173	.548	.569	4.605
$\Delta ln(Lev.)$	361	.017	.169	-1.101	.912
SRISK	367	3.101	4.330	1.000	19.957
ln(SRISK)	367	.579	.906	.000	2.994
$\Delta ln(SRISK)$	361	.024	.138	-.414	1.407
		CPP banks			
Total Assets	10164	1.45e+07	1.17e+08	67728	2.55E+09
ln(TA)	10164	14.231	1.347	11.123	21.647
$\Delta ln(TA)$	10034	.015	.054	-.382	2.048
Lev.	576	11.050	10.027	1.070	100.000
ln(Lev.)	576	2.164	.662	.067	4.605
$\Delta ln(Lev.)$	567	.053	.254	-.9141	1.444
SRISK	576	1.640	2.161	1.000	17.817
ln(SRISK)	576	.254	.519	.000	3.085
$\Delta ln(SRISK)$	567	.025	.123	-.421	1.407

Table 2.3: Differences in mean

	N(Others)	Mean(Others)	N(I)	Mean(I)	Diff.	se	t	p-value
				LOLR				
$\Delta ln(TA)$	38749	.0131	1843	.0058	-.0073	.0023	-3.5225	.0000
$\Delta ln(Lev)$	2808	.0029	187	.0634	.0605	.0214	2.8217	.0053
$\Delta ln(SRISK)$	2808	.0017	187	.0416	.0398	.0093	4.2843	.0000
				DW				
$\Delta ln(TA)$	39069	.0131	1523	.0029	-.0102	.0023	-4.323	.0000
$\Delta ln(Lev)$	2903	.0074	92	-.0164	-.0238	.0089	-2.6705	.0087
$\Delta ln(SRISK)$	2903	.0044	92	-.0016	-.0060	.0069	-.8794	.3811
				TAF				
$\Delta ln(TA)$	40272	.0127	320	.0198	.0070	.0034	2.0417	.0419
$\Delta ln(Lev)$	2900	.0023	95	.1407	.1384	.0397	3.4850	.0007
$\Delta ln(SRISK)$	2900	.0016	95	.0834	.0818	.0157	5.2113	.0000
				SIFIs				
$\Delta ln(TA)$	39841	.0103	751	.0128	.0024	.0019	1.231	.2184
$\Delta ln(Lev)$	2385	-.0176	610	.0129	.0306	.0086	3.5724	.0004
$\Delta ln(SRISK)$	2385	.0009	610	.0051	.0041	.0070	.5879	.5568
				Reg. Pressure				
$\Delta ln(TA)$	28540	.0145	12052	.0087	-.0057	.0008	- 6.7165	.0000
$\Delta ln(Lev)$	2634	.0085	367	.0170	.0085	.0111	.7694	.4421
$\Delta ln(SRISK)$	2634	.0037	367	.0242	.0204	.0088	2.3060	.0217
				CPP banks				
$\Delta ln(TA)$	38276	.0133	2316	.00347	-.0098	.0012	- 7.7137	.0000
$\Delta ln(Lev)$	2419	.0114	576	-.0113	-.0227	.0273	-.8307	.4071
$\Delta ln(SRISK)$	2419	.0055	576	.0121	.0065	.0089	.7378	.4614

Table 2.4: Correlation matrix

Panel A: Correlation -whole sample-

	(1)								
	Total Assets	ln(TA)	$\Delta ln(TA)$	Lev.	ln(Lev.)	$\Delta ln(Lev)$	SRISK	ln(SRISK)	$\Delta ln(SRISK)$
Total Assets	1	0.456***	0.00295	0.280***	0.302***	-0.0173	0.829***	0.831***	0.0554**
ln(TA)	0.456***	1	0.0300***	0.272***	0.375***	0.00269	0.500***	0.585***	0.0434*
$\Delta log(TA)$	0.00295	0.0300***	1	-0.0923***	-0.101***	0.0643***	-0.0615***	-0.0574**	0.0932***
Lev.	0.280***	0.272***	-0.0923***	1	0.433***	0.259***	0.134***	0.172***	0.0995***
ln(Lev.)	0.302***	0.375***	-0.101***	0.433***	1	0.129***	0.359***	0.462***	0.0860***
$\Delta ln(Lev)$	-0.0173	0.00269	0.0643***	0.259***	0.129***	1	-0.0178	-0.000869	0.326***
SRISK	0.829***	0.500***	-0.0615***	0.134***	0.359***	-0.0178	1	0.937***	0.0913***
ln(SRISK)	0.831***	0.585***	-0.0574**	0.172***	0.462***	-0.000869	0.937***	1	0.135***
$\Delta ln(SRISK)$	0.0554**	0.0434*	0.0932***	0.0995***	0.0860***	0.326***	0.0913***	0.135***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Panel B: Correlation by groups

	LOLR		**SIFIs**		**Reg.Pressure**		**CPP banks**	
	$\Delta ln(Lev.)$	$\Delta ln(SRISK)$	$\Delta ln(Lev.)$	$\Delta ln(SRISK)$	$\Delta ln(Lev.)$	$\Delta ln(SRISK)$	$\Delta ln(Lev.)$	$\Delta ln(SRISK)$
$\Delta lnTA)$	-0.1262	0.4337	0.1084	0.2571	0.0563	0.1786	0.0962	0.1599
$\Delta ln(Lev.)$	1	0.2817	1	0.3608	1	0.1894	1	0.3378

Table 2.5: Pro-cyclicality of leverage

	(1) $\Delta ln(Lev_t)$ b/se	(2) $\Delta ln(Lev_t)$ b/se	(No-crisis) $\Delta ln(Lev_t)$ b/se	(Crisis) $\Delta ln(Lev_t)$ b/se
$ln(Lev_{t-1})$	-.0330***	-.0357***	-.0270***	-.0651***
	(.0048)	(.0059)	(.0044)	(.0163)
$\Delta ln(TA_t)$	.1440***	.2364***	.0920*	.4072**
	(.0527)	(.0642)	(.0502)	(.1637)
Constant	.0675***	.0764***	.0468***	.1748***
	(.0098)	(.0123)	(.0091)	(.0357)
Year– Quarter FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Fed Reserve district FE	No	Yes	Yes	Yes
Observations	2907	2214	1635	579
No. of groups	80	77	76	56
R^2	.0516	.1168	.0693	.0899
F-test	59.81***	105.48***	87.28***	43.69***

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table reports panel regressions of quarterly leverage growth rates on the lagged level of leverage and the growth rates of assets distinguishing by crisis and no-crisis periods. Results are robust with Federal Reserve district fixed effects.

Table 2.6: Pro-cyclicality of leverage by groups

	(1) $\Delta ln(Lev)$ b/se	(2) $\Delta ln(Lev)$ b/se	(3) $\Delta ln(Lev)$ b/se	(4) $\Delta ln(Lev)$ b/se
$ln(Lev_{t-1})$	-.1693***	-.1185***	-.1337***	-.1328***
	(.0102)	(.0107)	(.0097)	(.0112)
$\Delta ln(TA_t)$	.1441*	.2240***	.3889***	.4898***
	(.0742)	(.0693)	(.0686)	(.0988)
LOLR	.1432***			
	(.0127)			
$\Delta ln(TA_t) * LOLR$	.4220***			
	(.1520)			
SIFIs		-.0358***		
		(.0130)		
$\Delta ln(TA_t) * SIFIs$		.4475*		
		(.2372)		
Reg. Pressure			.0251	
			(.0165)	
$\Delta ln(TA_t) * Reg.Pressure$			-1.2979***	
			(.2119)	
CPP banks				.0089
				(.0087)
$\Delta ln(TA_t) * CPP$				-.3848***
				(.1301)
Constant	.3192***	.2366***	.2566***	.2500***
	(.0197)	(.0199)	(.0192)	(.0198)
Year-Quarter FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Observations	2907	2907	2907	2907
No. of groups	80	80	80	80
F-test	228.3319***	216.4125***	255.1916***	217.5914***

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table reports panel regressions of quarterly leverage growth rates on the lagged level of leverage, the growth rates of assets and the interactions between the growth in assets and a dummy for four groups: banks participating into Federal Reserve's liquidity programs, SIFIs, regulatory constrained banks and banks participating into the Treasury's CPP program. Results are robust with Federal Reserve district fixed effects.

Table 2.7: Pro-cyclicality of leverage by groups –Crisis and no-crisis periods–

	Panel A: no-crisis				Panel B: crisis			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	$\Delta ln(Lev)$	$\Delta ln(Lev)$	$\Delta ln(Lev)$	$\Delta ln(Lev)$	$\Delta ln(Lev)$	$\Delta ln(Lev)$	$\Delta ln(Lev)$	$\Delta ln(Lev)$
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
$ln(Lev_{t-1})$	-.1878***	-.1326***	-.1545***	-.1440***	-.2837***	-.2194***	-.2001***	-.5303***
	(.0116)	(.0120)	(.0111)	(.0125)	(.0265)	(.0322)	(.0249)	(.0445)
$\Delta ln(TA_t)$	.1871**	.2642***	.4057***	.5964***	.2601	.5376***	.9526***	1.0092***
	(.0819)	(.0761)	(.0748)	(.1130)	(.2454)	(.1881)	(.2057)	(.2311)
LOLR	.1403***				.2932***			
	(.0136)				(.0361)			
$\Delta ln(TA_t) * LOLR$	.3723**				.5760			
	(.1632)				(.3628)			
SIFIs		-.0612***				.0805*		
		(.0144)				(.0482)		
$\Delta ln(TA_t) * SIFIs$		.3572**				4.8702***		
		(.1562)				(1.5339)		
Reg. Pressure			.0523***				.0725	
			(.0189)				(.0664)	
$\Delta ln(TA_t) * Reg.Press.$			-1.4258***				-2.2479***	
			(.2562)				(.5360)	
CPP banks				-.0089				.1624***
				(.0098)				(.0341)
$\Delta ln(TA_t) * CPP$				-.4929***				-1.3775**
				(.1450)				(.6214)
Constant	.3669***	.2842***	.3060***	.2971***	.5775***	.4783***	.4339***	1.1280***
	(.0231)	(.0231)	(.0226)	(.0229)	(.0546)	(.0630)	(.0543)	(.0892)
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fed Reserve district FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1635	1635	1635	1635	579	579	579	579
No. of groups	76	76	76	76	56	56	56	56
F-test	337.7478***	230.9522***	250.6177***	228.9123***	155.6132***	94.8890***	98.5011***	188.4328***

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table reports panel regressions of quarterly leverage growth rates on the lagged level of leverage, the growth rates of assets and the interactions between the growth in assets and four groups: banks participating in Federal Reserve's liquidity programs, SIFIs, banks under regulatory pressure and banks participating in Treasury's CPP program.

Table 2.8: Drivers for ΔLev

	(1) $\Delta ln(Lev_t)$ b/se	(2) $\Delta ln(Lev_t)$ b/se	(3) $\Delta ln(Lev_t)$ b/se	(4) $\Delta ln(Lev_t)$ b/se	(5) $\Delta ln(Lev_t)$ b/se
$ln(Lev_{t-1})$	-.1305***	-.1316*	-.2330***	-.0564	-.1438***
	(.0172)	(.0674)	(.0247)	(.0368)	(.0214)
$\Delta ln(repo_t)$	-.0824	-.9108**	.5253**	-.1707	-.0011
	(.1191)	(.4075)	(.2406)	(.2004)	(.1458)
$\Delta ln(FedRepo_t)$	.0083**	.0310***	.0151	-.0007	.0098***
	(.0035)	(.0110)	(.0104)	(.0048)	(.0038)
$\Delta ln(CP_t)$	-.0089*	-.0293	-.0340*	.0037	-.0109*
	(.0051)	(.0190)	(.0180)	(.0090)	(.0057)
$\Delta ln(Interbank_t)$	.1976***	.6425**	.3130	.0853	.1700**
	(.0604)	(.2829)	(.2536)	(.1326)	(.0685)
LOLR	.0682***		.1167**	-.0292	.0419
	(.0263)		(.0531)	(.0794)	(.0299)
Constant	.0672	-.3382**	.4265**	.0084	.1304**
	(.0441)	(.1588)	(.1841)	(.0650)	(.0508)
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Fed Reserve district FE	Yes	Yes	Yes	Yes	Yes
Observations	1958	162	548	260	1405
No. of groups	74	38	23	29	67
R^2	.0480	.0735	.1308	.0353	.0634
F-test	78.9412***	18.9217***	132.0315***	8.8009	68.1225***

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table reports panel regressions of quarterly leverage growth rates on the lagged level of leverage, the growth rates of repo, repo with the Federal Reserve, the issue of Commercial paper, wholesale funding and participation in the Fed's liquidity programs. Results are robust with Federal Reserve district fixed effects.

Table 2.9: Pro-cyclicality of systemic risk

	(1) $\Delta ln(SRISK_t)$ b/se	(2) $\Delta ln(SRISK_t)$ b/se	(3) $\Delta ln(SRISK_t)$ b/se	(4) $\Delta ln(SRISK_t)$ b/se	(5) $\Delta ln(SRISK_t)$ b/se
$ln(SRISK_{t-1})$	-.0087**	-.0115***	-.0079**	-.0097***	-.0088**
	(.0035)	(.0035)	(.0038)	(.0035)	(.0036)
$\Delta ln(TA_t)$	.1956***	.0739*	.1667***	.2270***	.2606***
	(.0403)	(.0438)	(.0418)	(.0432)	(.0551)
$\Delta ln(TA_t) * LOLR$		.6937***			
		(.1026)			
LOLR		.0359***			
		(.0086)			
$\Delta ln(TA_t) * SIFIs$			.4367***		
			(.1561)		
SIFIs			-.0020		
			(.0057)		
$\Delta ln(TA_t) * Reg.Press.$				-.2756**	
				(.1138)	
Reg. Pressure				.0176***	
				(.0062)	
$\Delta ln(TA_t) * CPP$					-.1459*
					(.0807)
CPP banks					-.0006
					(.0046)
Constant	.0025	.0024	.0025	.0004	.0028
	(.0024)	(.0024)	(.0026)	(.0025)	(.0035)
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Observations	2907	2907	2907	2907	2907
No. of groups	80	80	80	80	80
F-test	31.6988***	104.5091***	39.8322***	41.9457***	35.6568***

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table reports panel regressions of quarterly systemic risk growth rates on the lagged level of systemic risk, the growth rates of assets and the interactions between the growth in assets and three groups: banks participating into Federal Reserve's liquidity programs, SIFIs, banks under regulatory pressure and banks which have participated into the Treasury's CPP program.

Table 2.10: Pro-cyclicality of systemic risk by groups –Crisis and no-crisis periods–

	Panel A: no-crisis				Panel B: crisis			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	$\Delta ln(SRISK_t)$	$\Delta ln(SRISK_t)$	$\Delta ln(SRISK_t)$	$\Delta ln(SRISK_t)$	$\Delta ln(SRISK_t)$	$\Delta ln(SRISK_t)$	$\Delta ln(SRISK_t)$	$\Delta ln(SRISK_t)$
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
$ln(SRISK_{t-1})$	-.1459***	-.1499***	-.1426***	-.0055	-.1956***	-.1898***	.0144*	.0201**
	(.0348)	(.0367)	(.0371)	(.0065)	(.0169)	(.0199)	(.0092)	(.0080)
$\Delta ln(TA_t)$	.0662*	.0024	.0440*	.0850*	.1839**	.5676***	.5140***	.6562***
	(.0353)	(.0236)	(.0255)	(.0485)	(.0905)	(.0734)	(.0794)	(.0799)
$\Delta ln(TA_t) * LOLR$	-.0866				.8158***			
	(.0780)				(.1340)			
LOLR	.0093				.0765***			
	(.0091)				(.0144)			
$\Delta ln(TA_t) * SIFIs$		.5164***				.0986		
		(.1459)				(.4380)		
SIFIs		.0186				.0514***		
		(.0122)				(.0180)		
$\Delta ln(TA_t) * Reg.Press.$			.3132				.6586***	
			(.3397)				(.2186)	
Reg. Pressure			-.0018				.0194	
			(.0095)				(.0144)	
$\Delta ln(TA_t) * CPP$				.3553**				-.4312**
				(.1631)				(.2125)
CPP banks				-.0200***				-.0218**
				(.0061)				(.0108)
Constant	.0395***	.0349***	.0389***	.0034*	.0537***	.0529***	.0054	.0141**
	(.0099)	(.0079)	(.0115)	(.0018)	(.0065)	(.0065)	(.0059)	(.0065)
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1924	1924	1924	1924	579	579	579	579
No. of groups	76	76	76	76	56	56	56	56
F-test	11.9753***	16.7390***	17.0693***	15.3625***	65.45***	44.72***	82.40***	78.27***

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This table reports panel regressions of quarterly systemic risk growth rates on the lagged level of systemic risk, the growth rates of assets and the interactions between the growth in assets and four groups: banks participating in Federal Reserve's liquidity programs, SIFIs, banks under regulatory pressure and banks participating in the Treasury's CPP program. Results are robust with Federal Reserve district fixed effects.

Table 2.11: Targeting SRISK

	LOLR		SIFIs		Reg. Pressure		CPP	
	(Lev¡12.5) $\Delta ln(SRISK_t)$ b/se	(Lev≥ 12.5) $\Delta ln(SRISK_t)$ b/se	(Lev¡12.5) $\Delta ln(SRISK_t)$ b/se	(Lev≥ 12.5) $\Delta ln(SRISK_t)$ b/se	(Lev¡12.5) $\Delta ln(SRISK_t)$ b/se	(Lev≥ 12.5) $\Delta ln(SRISK_t)$ b/se	(Lev¡12.5) $\Delta ln(SRISK_t)$ b/se	(Lev≥ 12.5) $\Delta ln(SRISK_t)$ b/se
$ln(SRISK_{t-1})$	-.0609	-.0131***	-.0634	-.0097**	-.0972**	-.0109***	-.0630	-.0997***
	(.0425)	(.0037)	(.0437)	(.0040)	(.0484)	(.0038)	(.0427)	(.0088)
$\Delta ln(TA_t)$	-.0204	.0782	-.0225	.1894***	-.0244	.2686***	.0041	.2690***
	(.0462)	(.0505)	(.0467)	(.0476)	(.0442)	(.0495)	(.0979)	(.0595)
$\Delta ln(TA_t) * LOLR$	-.0465	.7121***						
	(.1727)	(.1107)						
LOLR	.0003	.0385***						
	(.0088)	(.0095)						
$\Delta ln(TA_t) * SIFIs$			-.0156	.4600***				
			(.1475)	(.1710)				
SIFIs			-.1330**	.0001				
			(.0625)	(.0062)				
$\Delta ln(TA_t) * Reg.Press.$					.0169	-.3505***		
					(.5839)	(.1227)		
Reg. Pressure					.0000	.0185***		
					(.)	(.0067)		
$\Delta ln(TA_t) * CPP$							-.0330	-.1572*
							(.1096)	(.0957)
CPP banks							-.0007	.0170***
							(.0072)	(.0055)
Constant	.0188	.0033	.0447	.0027	.0268	.0006	.0196	.0167***
	(.0255)	(.0027)	(.0285)	(.0029)	(.0297)	(.0028)	(.0262)	(.0040)
Observations	200	2585	200	2585	200	2585	200	2585
No. of groups	26	66	26	66	26	66	26	66
R^2	.1149	.1310	.1262	.2160	.1690	.2740	.1191	.2131
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.12: Drivers for ΔSRISK

	(1) LOLR b/se	(2) SIFIs b/se	(3) Reg. Pressure b/se	(4) CPP banks b/se
$ln(SRISK_{t-1})$	-.2508***	-.2182***	-.0884***	-.7117***
	(.0627)	(.0504)	(.0133)	(.1292)
Interbank	.9531*	.0015	.7819	.1913***
	(.5303)	(.2364)	(.5257)	(.0631)
Investment b.	-.1279*	.3137	-.2052**	.7288
	(.0690)	(.5744)	(.0841)	(.6450)
Derivatives	.1350**	-.1806	.0843	-.1060***
	(.0503)	(.1303)	(.1421)	(.0072)
Repo	-.7132	.3614*	.1050	.2679*
	(.4937)	(.1887)	(.1167)	(.1331)
FedRepo	.6058***	-.1395	.2930**	.5322*
	(.2154)	(.0903)	(.1153)	(.2741)
Com. Pap.	-.1442*	-.8134	-.8455	-.7797*
	(.0825)	(.4868)	(.8029)	(.4428)
Tier 2	-.2107***	.1559*	-.2618	-.8561
	(.0548)	(.0849)	(.7686)	(.8147)
Z-score	.2333*	.2895	.1874***	-.2980
	(.1186)	(.2647)	(.0178)	(1.6967)
Loans Comm.	.8678***	.8992**	.0314	.1431
	(.2710)	(.3925)	(.2977)	(.1541)
Constant	.2119***	.1451***	.0898***	.2911***
	(.0621)	(.0494)	(.0088)	(.0553)
Year-Quarter FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Observations	123	444	154	157
No. of groups	33	22	20	26
R^2	.5136	.3071	.1978	.6825
F-test	51.4588***	28.6814***	70.2789***	110.2008***

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.13: Structural equation: borrowers from Fed's liquidity programs

	(1) LOLR b/se	(2) LOLR b/se	(3) TAF b/se	(4) TAF b/se	(5) DW b/se	(6) DW b/se
$\Delta ln(Lev_t)$						
$ln(Lev_{t-1})$	-.0934***	-.1023***	-.0555***	-.0878***	-.0836***	-.1080***
	(.0190)	(.0189)	(.0155)	(.0165)	(.0188)	(.0193)
$\Delta ln(TA_t)$	.0804**	.9555**	.8601***	.7880***	.1665***	.8920*
	(.0485)	(.4852)	(.0310)	(.0353)	(.0405)	(.4837)
$\Delta ln(TA_t) * I$	.1556**	.6409***	.3942**	.4790**	-.1362***	-.1702**
	(.0750)	(.0747)	(.1993)	(.1991)	(.0431)	(.0747)
I	.0448*	.0474*	-.0260	-.0353	.0909	.0792***
	(.0252)	(.0250)	(.0459)	(.0458)	(.0554)	(.0301)
Treasury rate	.1087***	.1158***	.0799**	.1490***	.1866***	.1126***
	(.0412)	(.0410)	(.0331)	(.0366)	(.0320)	(.0411)
CP rate	-.0775**	-.0858**	-.0517*	-.1229***	-.1491***	-.0815**
	(.0383)	(.0382)	(.0303)	(.0336)	(.0297)	(.0382)
GDP	-.0044	-.0046	-.0018	-.0027	-.0048	-.0038
	(.0050)	(.0050)	(.0051)	(.0051)	(.0043)	(.0049)
Bond I.	.3268***	.3122***	.3335***	.2816***	.3429***	.3319***
	(.0711)	(.0707)	(.0666)	(.0694)	(.0603)	(.0705)
Crisis	.2748***	.2802***	.2811***	.3352***	.3588***	.2665***
	(.0394)	(.0392)	(.0317)	(.0340)	(.0331)	(.0392)
Pledged Sec.	-.0035	-.0027	-.0044	-.0022	-.0017	-.0032
	(.0039)	(.0039)	(.0036)	(.0038)	(.0032)	(.0038)
Constant	-1.8055***	-1.7054***	-1.9226***	-1.5532***	-1.9511***	-1.8073***
	(.4554)	(.4527)	(.4268)	(.4457)	(.3824)	(.4513)
$\Delta ln(SRISK_t)$						
$ln(SRISK_{t-1})$	-.0277***	-.0268***	-.0199**	-.0282***	-.0258***	-.0256***
	(.0074)	(.0083)	(.0079)	(.0079)	(.0074)	(.0086)
$\Delta ln(TA_t)$		.1871***		.2529***		.1905***
		(.0343)		(.0267)		(.0354)
$\Delta ln(Lev_t)$	.6236***		.6595***		.7796***	
	(.0701)		(.0432)		(.0697)	
$\Delta ln(TA_t) * I$	.9291**	.6464**	.4700**	.6597***	.1017***	.1135*
	(.4672)	(.2675)	(.1773)	(.1610)	(.0139)	(.0588)
$\Delta ln(Lev_t) * I$	-.4447***	.1791**	-.1697**	-.1695***	.4612***	.2939***
	(.1152)	(.0732)	(.0954)	(.0548)	(.0986)	(.0758)
I	.0408**	.0379**	.0207	.0096	.0832*	.0473**
	(.0176)	(.0191)	(.0405)	(.0366)	(.0470)	(.0237)
Cpi	.0002	-.0010	.0004	-.0015	.0010	-.0010
	(.0011)	(.0012)	(.0012)	(.0012)	(.0011)	(.0012)
Vix	.1234***	.1125***	.1457***	.1264***	.1173***	.1151***
	(.0201)	(.0222)	(.0220)	(.0215)	(.0224)	(.0233)
S&P	.0877**	.1224***	.0693	.1388***	.0617	.1145**
	(.0401)	(.0443)	(.0424)	(.0410)	(.0399)	(.0458)
GDP	-.0062*	-.0090**	-.0089**	-.0106***	-.0046	-.0087**
	(.0036)	(.0039)	(.0045)	(.0040)	(.0038)	(.0040)
Loans to US	.0010	.0029	.0022	.0016	.0010	.0033*
	(.0018)	(.0019)	(.0019)	(.0019)	(.0017)	(.0020)
Domestic A.	-.0010**	-.0008	-.0008*	-.0009*	-.0010**	-.0008
	(.0005)	(.0005)	(.0005)	(.0005)	(.0005)	(.0005)
DFA	-.0434*	-.0334	-.0646***	-.0279	-.0486**	-.0349
	(.0226)	(.0247)	(.0248)	(.0246)	(.0228)	(.0257)
Crisis	-.0676***	.0133	-.1190***	.0429**	-.1267***	-.0003
	(.0199)	(.0198)	(.0216)	(.0176)	(.0271)	(.0209)
Constant	-.3982*	-.5806**	-.3666	-.5654**	-.3335	-.5540**
	(.2325)	(.2535)	(.2493)	(.2517)	(.2328)	(.2634)
Observations	2356	2356	2356	2356	2356	2356
R^2	.1265	.1420	.1380	.1426	.2937	.1502
log(likelihood)	862.9754	791.5210	812.9312	808.6965	1005.9339	760.3719

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.14: Structural equation: systemic banks and banks with capital shortages

	(1) SIFIs b/se	(2) SIFIs b/se	(3) Reg. Pressure b/se	(4) Reg. Pressure b/se	(5) CPP banks b/se	(6) CPP banks b/se
$\Delta ln(Lev_t)$						
$ln(Lev_{t-1})$	-.0314*	-.0669***	-.0806***	-.1027***	-.0453**	-.0971***
	(.0177)	(.0177)	(.0152)	(.0164)	(.0187)	(.0186)
$\Delta ln(TA_t)$	.1791***	.1604***	.1520***	.1770***	.2853***	.2606***
	(.0345)	(.0360)	(.0303)	(.0348)	(.0450)	(.0451)
$\Delta ln(TA_t) * I$	.2587**	.1867*	-.4565***	-.4872***	-.1984**	-.2076**
	(.1067)	(.1039)	(.0976)	(.1022)	(.0959)	(.0935)
I	-.0252	-.0235	.1126***	.1376***	.0273	-.0132
	(.0173)	(.0194)	(.0169)	(.0360)	(.0255)	(.0323)
Treasury rate	.1000***	.1515***	.0818**	.1203***	.0996**	.1057***
	(.0353)	(.0362)	(.0319)	(.0353)	(.0395)	(.0382)
CP rate	-.0714**	-.1258***	-.0523*	-.0969***	-.0728**	-.0926***
	(.0326)	(.0335)	(.0292)	(.0323)	(.0362)	(.0350)
GDP	-.0045	-.0056	-.0083*	-.0095**	-.0047	-.0056
	(.0050)	(.0048)	(.0047)	(.0048)	(.0055)	(.0053)
Bond I.	.2848***	.2452***	.3247***	.2606***	.3002***	.2639***
	(.0708)	(.0695)	(.0625)	(.0664)	(.0805)	(.0809)
Crisis	.2874***	.3313***	.2747***	.2978***	.2703***	.2682***
	(.0333)	(.0334)	(.0309)	(.0336)	(.0381)	(.0378)
Pledged Sec.	-.0025	-.0014	.0019	.0021	-.0071	-.0026
	(.0038)	(.0039)	(.0035)	(.0037)	(.0044)	(.0043)
Constant	-1.6985***	-1.3805***	-1.9113***	-1.4638***	-1.7044***	-1.3945***
	(.4505)	(.4429)	(.4009)	(.4264)	(.5101)	(.5078)
$\Delta ln(SRISK_t)$						
$ln(SRISK_{t-1})$	-.0258***	-.0304***	-.0150*	-.0244***	-.0192**	-.0171**
	(.0084)	(.0083)	(.0082)	(.0081)	(.0075)	(.0076)
$\Delta ln(Lev_t)$	.4929***		.6860***		.3674***	
	(.0653)		(.0468)		(.0504)	
$\Delta ln(TA_t)$		.1389***		.1019***		.1477***
		(.0272)		(.0266)		(.0313)
$\Delta ln(TA_t) * I$	-.1419	-.1998	.4994***	.1641*	-.2413***	-.2259***
	(.09336)	(.9398)	(.0907)	(.0871)	(.0791)	(.0579)
$\Delta ln(Lev_t) * I$	.1961**	.1750***	-.1680**	-.1413**	.5317***	.4548***
	(.0827)	(.0495)	(.0740)	(.0625)	(.0839)	(.0702)
I	-.0024	-.0196	-.0062	.0558*	-.0376**	-.0514**
	(.0142)	(.0153)	(.0324)	(.0302)	(.0171)	(.0221)
Cpi	.0007	-.0001	.0019	-.0009	.0032***	.0037***
	(.0012)	(.0012)	(.0012)	(.0012)	(.0012)	(.0013)
Vix	.1385***	.1230***	.1462***	.1002***	-.0862**	-.0850**
	(.0234)	(.0216)	(.0169)	(.0212)	(.0360)	(.0368)
S&P	.0141	.0536	-.0052	.0775**	-.0073	.0235
	(.0358)	(.0349)	(.0356)	(.0338)	(.0359)	(.0363)
GDP	-.0065	-.0083**	-.0033	-.0084**	-.0074*	-.0088**
	(.0040)	(.0037)	(.0042)	(.0039)	(.0038)	(.0038)
Loans US banks	.0035*	.0033*	.0023	.0024	.0020	.0015
	(.0018)	(.0018)	(.0018)	(.0018)	(.0017)	(.0017)
Domestic A.	-.0009*	-.0009*	.0003	-.0001	-.0017***	-.0017***
	(.0005)	(.0005)	(.0005)	(.0005)	(.0005)	(.0005)
DFA	-.0439**	-.0233	-.0527**	-.0135	-.0377	-.0258
	(.0221)	(.0220)	(.0224)	(.0219)	(.0229)	(.0233)
Crisis	-.0843***	.0263	-.1141***	.0542***	-.0475**	.0132
	(.0223)	(.0177)	(.0213)	(.0177)	(.0221)	(.0194)
Constant	-.2060	-.3716*	-.3989*	-.5011**	-.1997	-.5446**
	(.2160)	(.2182)	(.2241)	(.2208)	(.2390)	(.2522)
Observations	2356	2356	2356	2356	2356	2356
R^2	.5800	.8882	.1649	.1148	.1908	.1095
log(likelihood)	832.2851	874.1461	898.5421	885.2198	770.6308	802.5549

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.15: Structural equation: interactions among programs

	(1) CPP & TAF b/se	(2) CPP & TAF b/se	(3) CPP & Low Cap. b/se	(4) CPP & Low Cap. b/se	(5) CPP & Nr b/se	(6) CPP & Nr b/se
$\Delta ln(Lev_t)$						
$ln(Lev_{t-1})$	-.2231***	-.2115***	-.1905***	-.2754***	-.0554***	-.0878***
	(.0491)	(.0429)	(.0482)	(.0687)	(.0165)	(.0161)
$\Delta ln(TA_t)$	.2080	.2482*	.7627***	.6938***	.2181***	.1931***
	(.1350)	(.1431)	(.2274)	(.2608)	(.0347)	(.0358)
$\Delta ln(TA_t) * I$	-.5133***	-.5496***	-.8407***	-.8679***	-.1481	-.1827
	(.1486)	(.1569)	(.2321)	(.2727)	(.1492)	(.1449)
I	.0200	.0099	-.0489	.1010	.0173	.0201
	(.1134)	(.1096)	(.0681)	(.1074)	(.0189)	(.0183)
Treasury rate	.2191	.0344	-.4278	.3375	.0984***	.1423***
	(.7559)	(.6014)	(1.0608)	(1.2739)	(.0359)	(.0355)
CP rate	-.1904	-.2840	.8109	.6972	-.0681**	-.1153***
	(.5450)	(.4533)	(.7445)	(.9288)	(.0329)	(.0325)
GDP	.0171	.0159	.0361*	.0495*	-.0040	-.0051
	(.0160)	(.0160)	(.0197)	(.0256)	(.0051)	(.0049)
Bond I.	.2232	.0970	.2713	1.0645*	.3356***	.2872***
	(.2092)	(.1999)	(.3075)	(.5580)	(.0721)	(.0702)
Crisis	.1085***	.1107***	.7592***	.8347***	.2901***	.3292***
	(.0123)	(.0117)	(.1347)	(.1770)	(.0338)	(.0332)
Pledged Sec.	-.0076	-.0132	-.0532**	-.0248	-.0036	-.0011
	(.0116)	(.0109)	(.0227)	(.0259)	(.0038)	(.0037)
Constant	-.7805	.0903	-.5563***	-.5725	-.1954***	-.1611***
	(.4011)	(.3299)	(.0386)	(.3539)	(.0462)	(.0459)
$\Delta ln(SRISK_t)$						
$ln(SRISK_{t-1})$	-.1839***	-.1947***	-.0850***	-.2400***	-.0231***	-.0284***
	(.0507)	(.0515)	(.0198)	(.0597)	(.0076)	(.0076)
$\Delta ln(Lev_t)$	.1087**		.1490*		.5087***	
	(.0526)		(.0885)		(.0439)	
$\Delta ln(TA_t)$		.5702***		.6130***		.1361***
		(.0542)		(.0577)		(.0278)
$\Delta ln(TA_t) * I$	-.3345***	-.1362**	.8132***	.2863***	-.9727	-.1524
	(.0215)	(.0645)	(.1034)	(.0591)	(.7967)	(.1250)
$\Delta ln(Lev_t) * I$	-.2009***	-.2227***	.0758***	.6701***	.3686***	.3625***
	(.0551)	(.0327)	(.0089)	(.1985)	(.1074)	(.0998)
I	-.2967	-.4828	.0049	-.1914	.0036	.0078
	(.3510)	(.4498)	(.0196)	(.1804)	(.0157)	(.0158)
Cpi	.0336	.0365	.0035	.0015	.0007	-.0002
	(.0335)	(.0359)	(.0054)	(.0408)	(.0012)	(.0011)
Vix	.3018	.0943	.1100***	.3048*	.1243***	.1026***
	(.2229)	(.2390)	(.0250)	(.1771)	(.0206)	(.0203)
S&P	-.7330	-.6353	-.0329	-.7071	.0701*	.1207***
	(.9479)	(.9519)	(.1596)	(1.3361)	(.0400)	(.0393)
GDP	-.0214	.0109	-.0009	-.0894*	-.0070*	-.0088**
	(.0506)	(.0632)	(.0071)	(.0514)	(.0040)	(.0038)
Loans US banks	.0401	.0428	.0086**	.0142	.0029	.0025
	(.0269)	(.0261)	(.0042)	(.0248)	(.0018)	(.0018)
Domestic A.	-.0172**	-.0144	-.0002	-.0229**	-.0008	-.0008
	(.0083)	(.0089)	(.0016)	(.0106)	(.0005)	(.0005)
DFA	-.1719	-.1752	-.0209	-.0988	-.0562**	-.0352
	(.2363)	(.2421)	(.0357)	(.2381)	(.0232)	(.0230)
Crisis	.1481***	.3128***	.0753	-.5509	-.0799***	.0366**
	(.0566)	(.0627)	(.0490)	(.3747)	(.0207)	(.0172)
Constant	-.1663	-.2885	-.4411	.9048	-.4401*	-.6634***
	(.3769)	(.4121)	(.6143)	(.5580)	(.2374)	(.2419)
Observations	193	193	223	223	292	292
R^2	.3430	.3401	.6047	.5944	.2000	.0692
log(likelihood)	-222.5835	-223.5616	140.4171	-57.4290	822.6377	858.8783

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Chapter 3

LOLR facilities and depositor discipline

This chapter analyses the presence of depositor discipline following the information disclosure of borrowers' name from the Federal Reserve liquidity facilities. Banks were reluctant to take funds from the Federal Reserve's Discount Window because in this way they would have been perceived as problematic banks on the market. Term Auction Facility, for that matter, has been introduced to face this "stigma" and provide further liquidity to the banks. Whether the presence of market discipline is well recognised in the literature, scarce is the evidence concerning depositor reactions following the participation in Lender Of Last Resort facilities. Using quarterly US data (FRY-9C) from 2006 to 2016 this chapter investigates if, following the contraction in the interbank market, BHCs used these funds as substitutes of wholesale deposits and whether the perception of financial instability has led to depositor discipline. Interestingly, results exhibit the presence of depositor reactions with differences among programs and type of deposits. Borrowers from Discount Window (from 2010 to 2014) exhibit a reduction in non-guaranteed and saving deposits a quarter after the access to the facility and the negative effect becomes larger when borrowers' names are effectively disclosed. Whilst borrowers from Term Auction Facility (from 2007 to 2010) experienced an increase in short term non-guaranteed deposits but the effect becomes mild once the information is disclosed. Depositor discipline on Discount Window borrowers is confirmed also from the higher risk-premium required by depositors two years after the borrowing period. Whilst, depositors of TAF-banks show deposit discipline in the form of higher interest rates. Moreover, the analysis on market share excludes the presence of herding effects in states different from states where headquarters are located.

3.1 Introduction

In August 2007,... banks were reluctant to rely on discount window credit to address their funding needs. The banks' concern was that their recourse to the discount window, if it becomes known, might lead market participants to infer weakness (the so-called "stigma" [Bernanke, 2009]

When the Federal Reserve was established, in 1913, there were no open market operations to conduct monetary policy. Instead, the Federal Reserve adjusted the money supply by lending directly to banks through the Discount Window (DW in what follows). As shown in Figure B.1, even if at the beginning the DW was used extensively and there appears to have been no mention of "stigma" attached to DW borrowing, in the long-run the access to DW has been scarce (Meulendyke, 1992; Peters, 2015; Federal Reserve Economic Data -FRED-). During the 2007-09 financial crisis, there has been a freezing in the interbank market (Figure 3.3), which generated problems for banks funding with a subsequent reduction in lending and liquidity buffers (Acharya and Skeie, 2011). Whilst deposits represent for banks the "stable" source of funding (among short-term funding), the interbank market is the most "immediate" source of bank liquidity within the banking system and thus an important indicator of the functioning of the banking market overall. Problems in the efficiency of interbank markets can lead to insufficient bank liquidity and, during crisis periods, a sudden reduction in the willingness or ability of banks to distribute reserves through interbank transactions has disrupted the short-term funding markets. In particular, banks of sound credit quality might have decided to scale back their term-lending to other banks because they were not as certain of either the creditworthiness of their counter-parties or their own ability to raise future funds (as a result, banks might have had limited access to term funds even if they were willing to pay high interest rates). In the late summer of 2007, following deteriorating performance in the market for mortgage-backed securities, (perceptions of) default risk rose and banks found it hard to roll over their uninsured debts. Amounts and maturities shrank in markets involving overnight lending between large banks, like the federal funds and LIBOR markets (Heider, Hoerova, and Holthausen, 2015; Gorton and Metrick, 2012; Covitz, Liang, and Suarez, 2013).

To improve liquidity in the funding markets, the Federal Reserve made a number of changes to its Discount Window facility and, in August 2007, this program has been revised: terms of lending were strongly favoured by reducing price of credit and allowing for longer borrowing period. With the bankruptcy of Lehman Brothers (October, the 15th 2008) the volume of borrowing requests from Discount Window increased dramatically. However, a growing literature is proving that, even if the Federal Reserve' aim was to regenerate the asset side of banks' balance sheets and solving liquidity problems, intermediaries that asked credit from this program suffered a "stigma" in the financial markets. That is, reliance on this type of facility was a signal of troubles with negative adverse effects on the stock markets (Fleming, 2012; Berger, 2014; Armantier et al., 2015; Wall, 2016). Consequently, there was reluctance to access the DW out of concerns that, if detected, depositors, creditors, or analysts could interpret DW borrowing as a sign of financial weakness. Moreover, in December 2007, the Fed introduced a temporary liquidity program, the Term Auction Facility (TAF), specifically designed to eliminate concerns of stigma attached to the DW. Under this facility banks bid for funds with (at least) other ten banks. As a result, and in contrast to the DW, the TAF was an immediate success in terms of amounts borrowed (Figure B2).

Initially the Federal Reserve decided not to reveal borrower's name under the reasoning that greater transparency would allow market participants and bank counter-parties to discipline banks and lead to avoidance of borrowing from the Lender Of Last Resort programs. However, regulators potentially have a different objective function than an individual firm. Bloomberg News and Fox News filed several lawsuits against the Federal Reserve under the Freedom of Information Act -FOIA- requesting access to the DW borrowing data during the financial crisis. On March 21, 2011, the Supreme Court ruled in their favour and, on March 31, 2011, forced the Federal Reserve to reveal which banks accessed the DW facilities, when they did so, how much they borrowed and for how long.[1] The presence of market discipline following DW borrowing has been deeply investigated in the literature (Furfine, 2003; Armantier et al., 2015), showing a negative market reaction for banks participating in the DW. Moreover, recent studies show that the decline in prices has happened not when the information has been released but when banks effectively borrowed from the facility (Berger, 2014; Kleymenova, 2015), meaning that the information was leaked or that market participants had been adept at understanding which banks borrowed.

In this chapter, we ask whether depositors react following the access to Federal Reserve's liquidity facilities generating a temporary reduction in deposits (calling off the effect of liquidity injection) or, even worst, leading to financial instability problems (Mishkin, 1999; Goodhart, 2009). Whether deposits have always been considered as a stable source of funding, the reason behind this research question arises from the fact that the recent financial crisis has opened again the debate concerning bank-runs (Moore, 1988; Demirguc-Kunt and Detragiache, 2002; Shin, 2009; Huang and Ratnovski, 2011; Beck et al., 2013; Vazquez and Federico, 2015). We conduct the analysis along the period 2006-2016 using quarterly consolidated balance sheet from FRY-9C at Bank Holding Company level. We differentiate among type of deposits in order to exploit the composition effect and shifting in the maturities: among others we consider demand deposits, liquid deposits, non-interest deposits, guaranteed and non-guaranteed deposits. Along the same vein, we check for depositors' discipline in the quarter following the access to the facility and at the announcement date (when borrower names have been disclosed). However, the unavailability of data on DW borrowers before 2010 prevents us from a specific comparison between the two

[1] For the news coverage, see, for example, Torres, Craig (2011), "Fed Releases Discount-Window Loan Records During Crisis Under Court Order" Bloomberg, March 31, 2011, available at http://www.bloomberg.com/news/2011-03-31/federal-reserve-releases-discount-window-loan-records-under- court-order.html

programs because there were differences in the surrounding real economy during the TAF period (2007-2010) and the DW period on which there are public information (2010-2014). Using 3SLS structural equations in order to take into account the demand and supply effects, results show that depositors of DW-banks effectively discipline their banks: in the quarter following the access to the facility the share of non-guaranteed and saving deposit diminishes and the effect is even larger when information on borrower's name has been released (eight quarters later). In general, the share of deposits which suffers more DW-stigma concerns time deposits. In the quarter in which information is released the share of domestic and saving deposits decreases by roughly 23 bp., whilst the share of non-guaranteed deposits decreases by about 40 basis points. The only sub-category of deposits which does not register neither an increase nor a decrease are guaranteed-deposits. Furthermore, depositors may discipline banks taking part in the Discount Window program also via interest rates. Our evidence shows that the unit-cost of deposits decreases for guaranteed and domestic deposits one quarter following the access to the facility (while no changes are shown for the unit-cost of non-guaranteed deposits). Eight quarters later, when information on borrowers' name is published, depositors discipline their banks by requiring a risk-premium on guaranteed and non-guaranteed deposits (penalising more the non-guaranteed ones, as expected).
Using the same methodology we analyse the behaviour of depositors of banks participating in the Term Auction Facility between 2007 and 2010. Among short-term deposits, our evidence shows that quarterly average of short-term deposits and non-guaranteed deposits that reprice within one year, increase in the quarter following the access to the facility (while when the information is disclosed the effect is still there but very mild in magnitude). All time deposits show a positive reaction following the bank access to the Term Auction liquidity program. As for short-term deposits the reaction is stronger in the quarter following the participation in the program: the effect persists for non-guaranteed and guaranteed deposits when the information is disclosed (in December 2010). However, even if depositors of TAF borrowers do not discipline their banks via quantities they do it via prices: unit-cost of domestic and non-guaranteed deposits increases following the access to the facility and persists when the information is disclosed, whilst there is no reaction on price of guaranteed deposits.
In the second phase of the analysis, using yearly data from the US Summary of Deposits provided by the FDIC, we check whether the results of the previous analysis remain, focusing on the change in the market share (in terms of deposits). We compare the results on the change in market-share, one and two years after the access to the facility, in the same state where the bank is headquartered and in the others. Using Fixed Effect regression and Propensity Score Matching (in order to control for bank observable characteristics *ex-ante*), our evidence shows that Discount Window borrowers reduce their market share in the state in which they are headquartered and, although the immediate effect, the market share suffers the larger losses in the year in which the information is disclosed. Nonetheless, results on bank's market share in other states but where the bank is headquartered, show no reduction in the year in which the BHC accesses the facility and an increase in the following years.

These results exclude the hypothesis of herding effects (results are confirmed from PSM when we control for selection on observables). When we conduct the market share analysis on banks which have participated into the Term Auction Facility program (from 2007 up to 2010), results exhibit that the market share increases in the year following the access to the facility and the magnitude becomes stronger overtime. However, evidence from Propensity Score Matching show the presence of "herding effect" with the increase happening also in the states in which the bank is not headquartered and with mild effect when the information on borrowers' name is disclosed.

This study contributes to the literature across several dimensions. First, it adds to the literature on the role and economic consequences of mandatory disclosure[2] investigating which are the net effects on financial stability and transparency. The unexpected nature of this disclosure allows us to exploit the exogenous variation resulting from the information shock and hence to draw causal inferences. Secondly, it opens again the debate on depositor sensitivity and the appropriateness of deposits guarantee schemes (Garcia, 1999; Gropp and Vesala, 2001; Demirguc-kunt and Detragiache, 2002). Third, it adds to the literature concerning the net benefits from liquidity injections: as long as participation in Lender Of Last Resort liquidity programs generate a decline in market prices and deposit contractions, we wonder what is the net benefit in the long term from these facilities.

The rest of this paper is organised as follows: Section 2 provides a brief history of the Discount Window and Term Auction Facility; Section 3 reviews the literature; Section 4 introduces the dataset and discusses the research design; Section 5 presents the empirical results and Section 6 concludes.

3.2 The institutional background

Bank financing in recent years has been characterised by the funding of long-term assets with short-term liabilities with the majority of short-term financing supplied by the repurchase agreement market (Adrian and Shin, 2009; Duffie, 2010; Gorton and Metrick, 2012; Van Rixtel and Gasperini, 2013; Adrian and Ashcraft, 2016). From the second quarter of 2007 to the first quarter of 2009, net repo financing provided to US banks and broker-dealers fell by about 1.3 trillion (more than half of its pre-crisis total), and as Gorton and Metrick (2012) report, a significant portion of the collateral underlying the repos was comprised of mortgage-backed securities. In few months, the market freezes and lenders of funds became increasingly concerned about losing money on repos because of worries about the value of the collateral as well as the credit risk of counter-parties. In order to respond to the financial crisis that emerged in the summer of 2007, the US Federal Reserve System and the Board of Governors used liquidity programs, credit programs and other monetary policy tools. In

[2]In this case we can consider the event as exogenous because our analysis investigates unexpected mandatory liquidity disclosures by a regulator, at the time of disclosure. Mandatory disclosure by a regulator is an interesting setting as it provides standardised information for all companies and is less likely to be influenced by the strategic behaviour of a particular bank.

particular, these programs fall into three broad categories: those aimed at addressing severe liquidity strains in key financial markets, those aimed at providing credit to troubled systemically important institutions, and those aimed at fostering economic recovery by lowering longer-term interest rates. The emergency liquidity programs that the Federal Reserve set up provided secured and mostly short-term loans. As financial markets stabilised, the Federal Reserve closed most of these programs: many of the programs were intentionally priced to be unattractive to borrowers when markets are functioning normally and, as a result, wound down as market conditions improved. The most famous and lasting program has been the Discount Window: originally the Discount Window was an overnight temporary loan, but on August 17, 2007, the Federal Reserve extended maturities beyond overnight (from 30 to 90 days); four months later, in order to solve the "stigma" associated with the DW (under which borrowers are perceived riskier or weaker), on December 12, 2007, the Federal Reserve introduced the Term Auction Facility. Both DW and TAF were addressed toward depository institutions, and in addition, the same institutions, namely, those deemed in sound financial condition by their Federal Reserve District Bank, had access to both facilities: funding was offered against the same collateral using identical haircuts calculations.[3]

Discount Window -DW-. In the US, the traditional way for the Federal Reserve to provide emergency credit to depository institutions is through the DW. Lending from the DW is in the form of "advances" which are loans evidenced by promissory notes of the borrowing bank and secured by adequate collateral. All depository institutions that maintain transaction accounts are entitled to borrow at the DW: these include any Federal Deposit Insurance Company (FDIC)-insured bank, savings or mutual bank, insured credit union, and US branch and agency of a foreign bank.

Prior to 2003, banks in distress could borrow from the DW at a rate below the Fed target rate. Because of the subsidised rate, the Fed was concerned about "opportunistic over-borrowing" by banks. Accordingly, before accessing the DW, a bank had to satisfy the Fed that it had exhausted private sources of funding and that it had a genuine business need for the funds. Hence, if market participants learned that a bank had accessed the DW, then they could conclude that the bank had limited sources of funding. The old DW regime therefore created a perception of "stigma" since DW borrowers revealed financial weakness to the Federal Reserve and possibly to competitors (Furfine, 2003). These concerns may have deterred banks from accessing the DW even if they had an urgent need for funds. This growing reluctance to borrow has impaired the functioning of the Discount Window because depository institutions preferred borrowing from the interbank market at high rates rather than from DW: this lead to the disappearance of the sensitivity of borrowing to the interest rate paid for borrowing (i.e. the "borrowing function"). The Federal Reserve's response to this challenge was to make

[3]No rules about executive compensation or dividend payments were applied to borrowers using Federal Reserve facilities. Executive compensation restrictions were imposed by statute on firms receiving assistance through the U.S. Treasury's Troubled Asset Relief Program (TARP). Dividend restrictions were the province of the appropriate supervisors and were imposed by the Federal Reserve on bank holding companies in that role, but not because of borrowing through these facilities.

changes to its lending program so that it would be more appealing to depository institutions (Artuc and Demiralp, 2010). To address concerns about DW stigma, the Fed fundamentally changed its DW policy on January 9, 2003. Under this new regulation (Regulation A) the Fed classified DW loans into: primary credit, secondary credit and seasoned credit.[4]Under primary credit, financially strong and well-capitalised banks can borrow under the primary credit program at a penalty rate (100 basis points above the Federal Open Market Committee's –FOMC– target rate). Because primary credit is available only to depository institutions in generally sound financial condition, it is generally provided with minimal administrative requirements (there are essentially no restrictions on the use of funds borrowed under primary credit -"no questions asked"-). The primary credit facility provides a backup source of funding if the market rate exceeds the primary credit rate, thereby limiting trading at rates significantly above the target rate. Secondary credit is available to depository institutions that are not eligible for primary credit. It is extended on a very short-term basis, typically overnight, at a rate 50 basis points above the primary credit rate. There are restrictions on the uses of secondary credit extensions (it may not be used to fund an expansion of the borrower's assets): credit is available to meet backup liquidity needs when its use is consistent with a timely return by the borrower to a reliance on market sources of funding or the orderly resolution of a troubled institution. Moreover, the secondary credit program entails a higher level of administration and oversight than the primary credit program and the Federal Reserve usually applies higher haircuts on collateral pledged to secure secondary credit. Despite these changes, DW borrowing remained sparse after 2003 and perceptions of stigma resurfaced at the onset of the recent financial crisis (Khandani and Lo, 2007). By the end of the summer of 2007, financial institutions were perceived to face serious liquidity shortages for term funding (Hilton and McAndrews, 2011). To encourage borrowing, the Fed reduced the DW penalty from 100 bps to 50 bps on August 17, 2007 and increased the term of DW financing from overnight to as long as 30 days. In addition, the Fed issued statements that DW borrowing would be viewed as a sign of strength and not a sign of weakness. An important change to its approach occurred in March 2008 after the Bear Stearns bailout, when the Fed reduced the penalty further to only 25 bp above the target FF rate.

Term Auction Facility -TAF-. In August 2007, amid widespread concerns about the condition of many financial institutions, investors became very reluctant to lend, especially at maturities beyond the very shortest terms. Unfortunately, the steps taken by the Federal Reserve by increasing the amount of liquidity through the Discount Window were not enough: many banks were reluctant to borrow at DW out of fear that their borrowing would become known and would be erroneously taken as a sign of financial weakness. To meet the demands for term funding more directly, the Federal Reserve announced the creation of the TAF on December

[4]The seasonal credit program assists small depository institutions in managing significant seasonal swings in their loans and deposits. Eligible depository institutions may borrow term funds from the discount window during their periods of seasonal need, enabling them to carry fewer liquid assets during the rest of the year and, thus, allow them to make more funds available for local lending. The interest rate applied to seasonal credit is a floating rate based on market rates. Seasonal credit is available only to depository institutions that can demonstrate a clear pattern of recurring intra-yearly swings in funding needs.

12, 2007.[5] With a few exceptions, the terms of the funds allocated were 28 days, and after August 11, 2008, 84 days. The TAF enabled the Federal Reserve to provide term funds to a broader range of counterparts and against a broader range of collateral than it could through open market operations. As a result, the TAF helped promote the distribution of liquidity when unsecured bank funding markets were under stress. All depository institutions that were eligible to borrow under the Federal Reserve's primary credit program (DW) were eligible to participate in the TAF.[6] All loans extended under the TAF were fully collateralised and the funds were allocated through an auction.[7] This emergency facility was considered temporary, for use in a crisis, and thus only the DW facility lasted beyond 2010 (the penalty on DW loans was reset to 100 bp).

All Fed liquidity programs were used more heavily after the bankruptcy filing of Lehman Brothers on September 15, 2008, however borrowing remained concentrated through the crisis, and some safer banks were absent from the Fed programs even after Lehman's collapse. Previous evidence (Taylor and Williams, 2009; Sarkar, 2010; Afonso et al., 2011; Benmelech, 2012) shows that weaker banks were significantly more likely to borrow from the Fed and that loan prepayments were not generally motivated by better market conditions, but rather by a desire among weaker banks to avoid investor scrutiny.

The information disclosure. At the time, the Federal Reserve was reluctant to release to the public information about the specific borrowers from its emergency lending programs, releasing neither the identity nor the amount borrowed either incrementally or entirely. The motivation for withholding information from the public about the identity of the borrowers and the amount borrowed appears to have been driven by fear that the news could have caused a bank-run on the borrowing institution. As anecdotal evidence of the idea that the Federal Reserve wanted to increase transparency while carefully managing the stigma associated with participation in the Fed lending programs, Chairman Ben Bernanke testified before the U.S. Congress in February 2010: *"We are also prepared to support legislation that would require the release of the identities of the firms that participated in each special [emergency lending] facility after an appropriate delay. It is important that the release occur after a lag that is sufficiently long that investors will not view an institution's use of one of the facilities as a possible indication of ongoing financial problems, thereby undermining market confidence in the institution or discouraging use of any future facility that might become necessary to protect the U.S. economy"*. After this testimony and in response to a Freedom of Information Act (FOIA) requested by Bloomberg LLP and

[5] A total of 60 TAF auctions were conducted every two weeks between December 17, 2007 and March 8, 2010 when the TAF program was terminated (with credit extended under that auction maturing on April 8, 2010). The amount of credit allocated by the Fed at each auction varied from 20 billion (initially) to 150 billion at the peak of the crisis.

[6] All U.S. depository institutions and U.S. branches and agencies of foreign institutions that maintain deposits subject to reserve requirements are eligible to borrow from the Federal Reserve's discount window. Of those institutions, primary credit, and thus also the TAF, is available only to institutions that are financially sound.

[7] According to this bi-weekly auction participating depository institutions placed bids specifying an amount of funds, up to a pre-specified limit -ten percent of the auction total -, and an interest rate that they would be willing to pay for such funds. The funds were allocated beginning with the highest interest rate offered until either all funds were allocated or all bids were satisfied. All borrowing institutions paid the same interest rate -stop-out rate-, either the rate associated with the bid that would fully subscribe the auction, or in the case that total bids were less than the amount of funds offered, the lowest rate that was bid. Unlike the DW, TAF loans could not be paid back prior to maturity and whereas DW loans are credited on the same day, TAF awards were only credited three days after the auction.

Fox Business Network, the Federal Reserve divulged detailed public information about the specific institutions that had participated in the emergency lending programs. This information not only identified the name of the borrowing institution and the date of the borrowing, but also included the incremental amount borrowed and the outstanding balance by date of new borrowing. This information was released to the public on December 1, 2010 and March 31, 2011 for the Term Auction Facility (TAF) and Discount Window (DW) borrowings, respectively.[8] The initial reporting period for Discount Window covers loans made between July 22, 2010 and September 30, 2010. Loan data for subsequent periods are published quarterly, with approximately two-year lag.

However, even if Federal Reserve loan data was kept secret prior to the Bloomberg FOIA lawsuit in 2011, some empirical papers show negative market reaction at the time of borrowing (Berger, 2014; Kleymenova, 2015). This could have happened because, if the amounts borrowed were large enough, banks would be required to disclose them in SEC filings (in fact, to avoid disclosure, banks would prefer to prepay loans immediately prior to the end of the fiscal reporting period).[9]

3.3 Literature Review

The literature related to this paper refers to depositors discipline, market reactions following information disclosure and the effects of Federal Reserve's liquidity programs (especially with reference to Term Auction Facility and the "stigma" associated to Discount Window).

Starting from the eighties depositor discipline has been deeply investigated in the literature (Flannery, 1982; Kane, 1987; Garten, 1988; Macey and Garrett, 1988; Macey and Miller, 1988; Brumbaugh et al., 1989; Mester, 1990). One of the first studies related to depositor discipline is the one by Douglas and Lewis (1994). Authors provide evidence of risk pricing of insured deposits: if there is risk pricing of guaranteed deposits, investors in deposit instruments evidently price the possibility of loss from incomplete or costly deposit insurance cov-

[8] On July 21, 2010, the Dodd-Frank Wall Street Reform and Consumer Protection Act was signed into law. The Dodd-Frank Act included changes that were designed to promote transparency while protecting monetary policy independence and the efficacy of the Federal Reserve's liquidity programs and open market operations (OMOs). As required by the Dodd-Frank Act, on December 1, 2010, the Federal Reserve disclosed detailed information about (i) entities that received loans or other financial assistance under a Section 13(3) credit facility between December 1, 2007, and July 21, 2010; and (ii) entities that [...] borrowed through the Term Auction Facility during that time frame. This information includes: the identity of the entities provided financial assistance under the facility, the type of financial assistance provided, the value or amount of the assistance, the date on which the assistance was provided, the specific terms of any repayment expected, including the repayment time period, interest charges, collateral, limitations on executive compensation or dividends, and other material terms and the specific rationale for the facility.

[9] The Federal Reserve's policy prior to the Dodd-Frank Act was that it would not disclose the names of banks that borrowed from the discount window, but it would publish a weekly total of borrowing by Reserve District. Nevertheless, considerable anecdotal evidence suggests banks believed that other banks would be able to identify which banks borrowed from the discount window. The Richmond Fed's Renee Courtoisis and Huberto M. Ennis suggest that given knowledge of borrowing in a district, "it would not be hard to infer" which bank is doing the borrowing based on the close relationships banks establish with one another in the interbank market.

erage. Moreover, a lot of studies have been conducted internationally studying depositors' reaction following a change in bank riskiness. Birchler and Maechler (2001), using bank-specific data on 250 Swiss banks from 1987 to 1998, test for the presence of saving depositors discipline following changes in bank's fundamentals. Authors find evidence of market discipline via quantities, in the sense that depositors react to fundamentals, institutional differences and changes in deposits guarantees schemes by withdrawing their deposits. Martinez-Peria and Schmukler (2001), using a sample of banks located in Argentina, Chile and Mexico from 1980 to 1990, study the interaction between market discipline and deposit insurance and the effects of banking crisis on market discipline. Results show that depositors effectively discipline their banks by requiring higher interest rates and by withdrawing deposits and that deposit insurance does not appear to diminish the extent of market discipline. Secondly, authors show that aggregate shocks affect deposits and interest rates during crisis, without distinguishing among banks' fundamentals. In the US market, Maechler and McDill (2002) test whether depositors penalise banks for poor performance by withdrawing their uninsured deposits. Their results support the existence of depositor discipline and risk-premium offered by the bank is not enough to stop a deposit drain. Goday et al. (2005) investigate depositors' reaction during the Uruguayan crisis studying the effect on the growth rate of deposits, changes in interest rates and by testing if depositors discipline banks by shortening the maturity of time deposits. Their findings show that depositors discipline riskier banks mainly by withdrawing their deposits and weaker evidence on the hypothesis that depositors require higher interest rates or reduce the maturity of time deposits as disciplining actions. For Russian banks along the period 2004-2006, Semenova (2007) investigates whether depositors react to changes in fundamentals by requiring higher interest rates, withdrawing their deposits or switching from long-term to short-term or on call deposits; moreover, the author deepens the analysis testing differences among group of banks (state, private and foreign) and whether depositors discipline disappears with banks' admission to deposit insurance system. Findings show that depositors of foreign banks exert no discipline by quantity or prices, whilst state-owned banks use quantity-based discipline mechanism and private domestic banks are disciplined either by withdrawing deposits and by requiring higher interest rates. Interestingly, the deposit insurance scheme performs by reducing the maturity-shift for time deposits for state-owned banks, whilst does not remove the disciplining effect for private domestic banks. Karas et al. (2010), demonstrate the presence of quantity-based sanctioning of weaker banks by firm and household before the deposit insurance in Russia. Moreover, deposit supply function show that deposit attraction diminishes following an increase in interest rates, especially for poorly capitalised banks (consistent with depositors interpreting the deposit rate as a proxy for bank-level risk). Berger and Turk-Ariss (2014) study the unintended consequences of a reduction in market discipline following the expansion in deposit insurance schemes. The authors, address for the presence of market discipline in US and EU and how discipline changes during the crisis: evidence shows the existence of depositor discipline and that it varies between US and EU, bank size, and listed versus unlisted status. Moreover, they effectively proved that depositor discipline decreases during the crisis in the US, especially for small banks. Chesini and Giarretta (2016), using a sample of banks located in 22 OECD countries from 2005 to 2014, build up a model for testing whether depositors discipline banks based on banks' riskiness and taking into account Deposit Insurance Schemes depending on where the bank is located. Results show that depositors do not discipline banks before and during the recent financial crisis, while they do it in the post-crisis period. In what concerns the literature related to depositor discipline and safety net, Demirguc-Kunt and Detragiache (2002), based on evidence for 61 countries between 1980-1997, find that Depositors Guarantee Schemes increase the probability of banking crisis. Moreover, this effect is larger when banks are mainly financed by insured depositors, when the Deposit Guarantee Scheme is run up by the government instead of the private sector, when bank interest rates are deregulated and when the institutional environment is weak.

Since TAF program was born in 2007, literature on it is scarce but is growing rapidly, whilst most of the literature concerning Federal Reserve's liquidity programs analyses the effects of Discount Window with event study methodology. Benmelech (2012) examines the role of foreign banks played in the TAF and finds that the foreign banks used the facility to a greater extent than domestic banks. Ennis and Weinberg (2013) show analytically that in the presence of information asymmetry about the quality of banks' assets, it is rational for banks to avoid using the DW facility to prevent signalling that their need for funding might be an indicator of poor asset quality. Armantier et al. (2015) study if the "stigma" associated with the Discount Window program was effectively proved. Comparing DW (*Primary Credit*) with TAF, repo and ABSCP they find that banks were willing to pay a premium of 37 bp for alternative funds in order to not use funds from DW (the cost that banks have to pay in order to avoid to be declared as "weak" banks). They also investigate the determinants of DW stigma and they find that banks outside New York, foreign banks, stress in financial markets have higher incidence on DW stigma. Berger et al. (2015) examine the joint use of TAF and DW investigating in which characteristics users of DW and TAF differ and which are the use of funds obtained with these programs. Using two sub-samples of small and large banks results show that smaller borrowers were weaker than their peers (while larger banks had no significant difference with their peers), that small banks increased lending at small business level and large banks enhanced large business lending (loan quality only improved at small banks). Boyson, Helwege and Jindra (2015) studying the liquidity framework and the bailout framework, find that TAF (among other programs) was used by relatively few institutions and had modest effects on the liquidity of short-term debt markets. Instead, evidence suggests that the decision to borrow and to prepay loans was related to each firm's financial health. Results suggest that healthy banks found the terms of the loans expensive relative to private market funds, while banks closer to insolvency generally did not. Thus, if bailouts are the primary factor in Fed lending, the use of the programs will be limited and skewed towards under-capitalized banks. Allen et al. (2016) study the effects of the modification in TAF facility starting from March 2008, like the increase in the amount of funding offered joint with the reduction in interest rates which allows this program to move from competitive auction to quantitative easing. Moreover, they study the uses of these funds from the community and non-community banks pointing out the financial crisis arises from non-community banks (non-community banks had short-term funding problems and the interbank funding was not of great importance for community banks as they rely mostly on core-deposits and non-equity funding sources).

Concerning the stock market reaction following the participation in these programs, Cyree, Griffiths, and Winters (2013) investigate the stock market impact of borrowing from the lender-of-last-resort facilities (DW and TAF), from the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility, the Primary Dealer Credit Facility, and the Commercial Paper Funding Facility. Distinguish among traditional banks, investment banks, and too-big-to-fail banks, they provide evidence of negative wealth effects for banks that participated in Fed crisis lending programs, suggesting this information was valuable to market participants. Blau at al. (2016) investigate the market's ability to accessing relevant information in order to influence prices. They find that, although the names of the institutions were not released until the completion of the program, public bank had negative cumulative abnormal returns around TAF loans. Authors show that when the details of this information were finally made public by the Fed, there was no stock market reaction, contrary to the thought that this was valuable information. The underperformance of borrowing institutions was more severe for those that received the largest loans or had the largest amount of loans outstanding. This evidence is consistent with the idea that investors could trade on the information about the Fed's emergency loan program, although the Fed purposely tried to keep the information private. Kleymenova (2016) studies the capital market consequences of unique and unexpected mandatory disclosures of banks' liquidity and the resulting changes in banks' behaviour. Employing a hand-collected sample of the disclosures of banks' borrowing from the US Federal Reserve Discount Window (DW) during the financial crisis, the author finds that these disclosures contain positive incremental market information as they decrease banks' cost of capital (measured by the equity bid-ask spreads and the cost of debt). However, the paper also evidences endogenous costs associated with more disclosure: banks respond to the DW disclosures by increasing their liquidity holdings and decreasing risky assets. In line with the theoretical predictions of Goldstein and Sapra (2013), this finding indicates that, following the DW disclosures, banks try to avoid accessing the DW facility. In fact, while more disclosure improves price efficiency and leads to market discipline in a setting without frictions, Goldstein and Sapra (2013) demonstrate analytically that this might not necessary be the case for banks. This is because banks operate in the "second-best" environment, due to their interconnected nature, the presence of externalities, and banks' exposure to informational and market frictions. Furthermore, they show that, in the second- best environment, the incentives of all market participants need to be taken into account arguing that while more disclosure might lead to better market discipline and price efficiency, it is a necessary but insufficient condition for economic efficiency because of the endogenous costs of disclosure. Similarly, Thakor (2012) analytically predicts that mandatory financial disclosure for financial institutions might be inefficient and lead to banks' fragility.

3.4 Identification strategy and methodology

Motivations. During the pre-crisis period banks started the reengineering of the liability side via the substitution of retail deposits by institutional investors financing (mainly in the form of repos as reported by Adrian and Shin, 2010). In other words, the traditional banking function of maturity transformer from short-term deposits to loans was still there, but the share of financier shifted consistently towards wholesale depositors. Figure 3.3 supports this view by showing the increase in wholesale financing before the recent financial crisis. However, from the second quarter of 2007 to the first quarter of 2009, net repo financing provided to US banks and broker-dealers fell by about 1.3 trillion (Gorton and Metrick, 2012): as soon as some banks have begun to default, banks that had direct deposits or repo with suffering banks have recorded losses immediately and, all the others, started to jointly withdraw their deposits (domino effect). This suggests that runs in the tri-party repo market may occur precipitously, like traditional bank runs, rather than manifest themselves as large increases in margins. In order to face liquidity needs, banks could access the Discount Window facility and moreover, in December 2007, the Federal Reserve announced the Term Auction Facility. Despite the fact that funds provided through the DW and TAF had the same collateral and eligibility requirements, banks borrowed substantially higher amounts during the financial crisis through the more expensive TAF and thus paid substantially more because of the perceived DW stigma (Brunnermeier, 2009; Haltom, 2011).

The presence of "stigma" associated to DW, the ease with which liquidity difficulties come to know on the market even before the information disclosure and the fact the banks relied heavily on wholesale borrowings, lead us to investigate if there has been depositor discipline following bank participation in Federal Reserve's

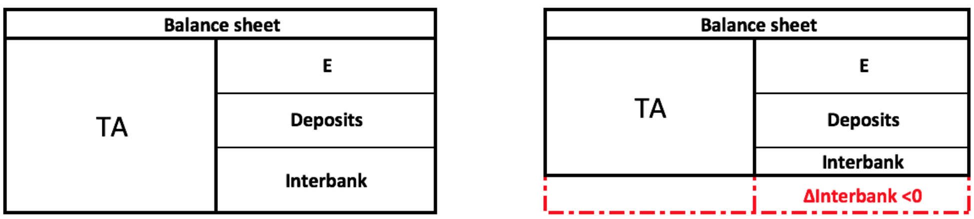


Figure 3.1: Stylized BS and crisis effects

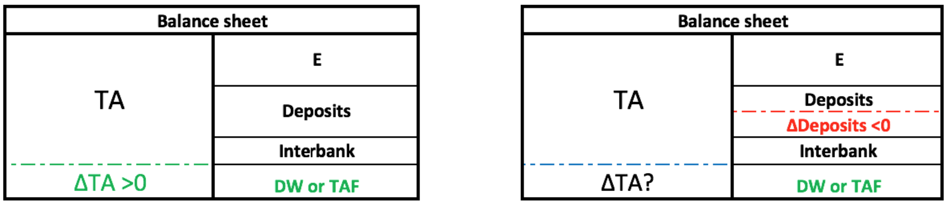


Figure 3.2: Depositors' reaction

liquidity emerging programs. In other words, when repos financing drained and banks had difficulties in rolling over short-term debt, one way to substitute these funds was to take advantage from Federal Reserve' programs. As shown in Figure 3.1 and 3.2, we ask whether the negative reaction perceived by the market (following the access to DW) was perceived also by (or transferred to) depositors. We identify depositors as an important source of market discipline. While debt-holders and shareholders can typically exert their influence on larger public banks, depositors are an important source of funding across all strata of banks, from small community banks to large, systemically important financial institutions. Uninsured depositors are particularly exposed to the risks of bank failure as they stand to lose a considerable amount of their unprotected deposit investment.[10] That is, provided that the aim of these emergency liquidity facilities was to alleviate short-term problems, did depositors react when news on liquidity difficulties propagated on the market? Or, have they been affected when information has been disclosed? If these predictions are true, then the net effects of these programs are controversial: bank-runs might call off benefits from liquidity injections. Following past crisis, the creation of a "safety net" in the form of deposit guarantee schemes and LOLR facilities, contribute to cushion the panic created by rumours considering deposits as a "stable" source of funding and voiding the likelihood of bank-runs. However, the recent financial crisis demonstrated that it is not always the case: the "bank-run" phenomenon effectively materialised again (especially for English banks, like Northern Rock) and in this paper we investigate if the "LOLR" component of a proper-designed safety net requires larger "deposit guarantee scheme" in order to function properly and avoid bank-runs.

Due to the lack of information on DW borrowers and TAF borrowers along the same period[11] we study the presence of deposit discipline for the two programs comparing them with respect to the control group (banks which did not participate) but we cannot compare them directly because of the different period they are referring to.

Structural Equation. In the first stage of the analysis we investigate the presence of deposit discipline, that is of a market-based incentive scheme in which uninsured (and insured) depositors punish banks for greater

[10] Large depositors have become an important source of retail funding for banks and their share of total deposits rose from around 30 percent in the mid-1990s to over 45 percent by the mid-2000s (Peristiani and Santos, 2014).

[11] We have information for all TAF auctions from December 2007 to March 2010 but we have information on Discount Window borrowers starting from January 2010.

risk-taking by demanding higher yields on those liabilities (or even worse, by withdrawing their deposits), via a structural equation model.[12] In general, it is very difficult to estimate the underlying structural parameters using standard methods due to endogeneity issues and non-linearities. For example, in order to estimate the borrowing function via least squares, we would need instruments for the equilibrium funds rate which is determined endogenously. Standard literature investigating the effects of bank riskiness on deposit discipline usually tackle endogeneity via dynamic panel (Arellano and Bond, 1991) using as instrument past changes in the dependent variable or past-values of the price of credit.[13] However, in our case the access to the Discount Window or Term Auction Facility acts as substitute of other short-term liabilities and modelling via dynamic panel could lead to infer as "deposit discipline" what truly is a "demand side effect".[14] Exploiting information on borrower's name, amount borrowed and cost of funds, we estimate a structural equation system via modelling the bank's *demand* of deposits and the *supply* of funds by depositors. Considering the standard determinants of the bank's demand of funds in the literature (Klein, 1974; Diamond and Dybvig, 1883; Bernanke and Blinder, 1988; Goldstein and Pauzner, 2005), we model the bank's *demand* of deposits equation by regressing the change in the volume of deposits -$\Delta ln(Deposits_{i,t})$- on the interest rate on deposits ($interest^{d}_{i,t-1}$), the price of competing fundings ($\mathbf{price^{c}_{i,t}}$), the *federal fund rate* as what in economics is defined as "the price of raw materials used to produce the product" and a set of bank characteristics in order to consider specific riskiness -$\mathbf{Bank_{i,t-1}}$-. Whilst, in the *supply* equation we include in the set of regressors the interest rate on deposits ($interest^{d}_{i,t}$), a proxy for macro-economic conditions, and a proxy of benefits from competing investments.

$$\begin{cases} \textbf{Demand}: \Delta ln(Deposits_{i,t}) = \alpha + \beta_1 ln(Deposits_{i,t-1}) + \beta_2 interest^{d}_{i,t-1} + \beta_3 * P_{i,t-1} + \beta_4 interest^{P}_{i,t-1} + \\ \qquad \beta_5 ln(amount^{P}_{i,t-1}) + \beta_6 ffr_t + \beta_7 \mathbf{Bank_{i,t-1}} + \beta_{\mathbf{8}} \mathbf{price^{c}}_{\mathbf{i,t-1}} + \alpha_{\mathbf{i}} + \epsilon_{\mathbf{i,t}} \\ \\ \textbf{Supply}: \Delta ln(Deposits_{i,t}) = \alpha + \beta_1 ln(Deposits_{i,t-1}) + \beta_2 interest^{d}_{i,t-1} + \beta_3 * P_{i,t-1} + \\ \qquad \beta_4 \mathbf{Macro_{i,t}} + \beta_{\mathbf{5}} \mathbf{RL_{i,t-1}} + \alpha_{\mathbf{i}} + \epsilon_{\mathbf{i,t}} \end{cases} \tag{3.1}$$

[12]For market discipline to be effective three conditions need to be satisfied. First, investors in bank liabilities need to consider themselves at risk of loss if the bank defaults. Second, market responses to changes in the bank's risk profile need to have cost implications for the bank. Third, the market must have adequate information to gauge the riskiness of the bank. Specifically, Rochet (1992), Blum (2002) and Cordella and Yeyati (1998) show that in the absence of corporate governance problems between bank shareholders and manager, if bank deposits are uninsured and the bank's risk choice is observable by depositors, the bank's risk choice will be efficient. The reason is that banks internalise the impact of their risk choice on depositors since these in turn will demand higher compensation if the bank incurs higher risk. In such a world, there is perfect market discipline and no moral hazard. Conversely, if deposits are insured or the bank's risk choice is not observable by depositors, then the bank will choose a higher than the efficient risk profile at the expense of depositors. The reason is that depositors will not demand a higher return in response to higher risk choices by the bank. In such a world there is no market discipline and the bank's choice of its risk of default is subject to moral hazard.

[13]see for example Martinez-Peria and Schmukler (2001); Maechler and McDill (2003); Karas et al. (2010); Berger and Turk-Ariss (2014).

[14]For robustness, we report results from dynamic panel regression in the Appendix.

with the number of banks $i = 1, ..., N$ and the quarter $t = 1, ..., T$. In Equation (1) the left-hand side variables are the first difference of the logarithm of deposits held by bank i at time t. We use growth rates instead of levels because, as Ioannidou and de Dreu (2006) suggest, the levels depend more on bank characteristics, than on supply and demand equality conditions, moreover, the levels may be biased to balance equality of assets and liabilities. To take into account the attrition effect we control for the log-level of deposits in the previous quarter ($Deposits_{i,t-1}$). $P_{i,t-1}$ stands for the participation in the liquidity facility for bank i in previous quarter, $P_{i,t} = \{DW; TAF\}$; while $interest^P_{i,t-1}$ and $ln(amount^P_{i,t-1})$ represent the average interest paid and amount borrowed from the Fed's emergency program in the previous quarter. Even if the treatment variable, $P_{i,t-1}$, could be considered as continuous (different dosage of DW or TAF funds) or dummy, in our study we consider the participation in the liquidity programs as an indicator variable. The idea behind this decision is coherent with the fact that we do not know if depositors react to "rumours" or following the information disclosure; thus, if information is biased and depositors react to a "signal" they would react when they know about banks' participation in the program independently from the amount borrowed.

In the demand equation, $\mathbf{Bank_{i,t}}$ is a vector of bank-specific variables assumed exogenous and included with a quarterly lag to account for the fact that financial reports are not instantaneously made available to the public and to reduce potential endogeneity concerns. Among them we alternatively exclude or include[15] the level in previous quarter of other funding sources, like commercial paper, repos, wholesale financing, and Tier2 because these are potentially endogenous. We consider that the decision of the bank depends also on the level of unused commitments on the loan side, the dimension of the bank, and on the level of capitalization (measured as Tier1 Capital). $\mathbf{price^c_{i,t-1}}$ is the vector of interest rates paid on competing sources of funding (like commercial papers). The inclusion of ffr_t allows us to interpret the effect of the interest rate as a deposit risk-premium. We allow for unobserved bank heterogeneity by introducing a bank-specific, time-invariant effect α_i. While in the supply side equation we model the decision to deposit depending on macro-economic condition (which influence the banking system as a whole –i.e., growing unemployment and lower wages lead families to save less–), on interest rates offered on deposits and on the bank's financial fragility perceived by depositors. $Macro_t$ variables do not depend on banks and bank fundamentals, but influence the depositors' decisions. In this vector we include GDP growth rate and CPI rate in order to take into account inflation, Vix rate which proxy the volatility and perceived financial instability in the market, Bond Index and S&P which influence the decision towards alternative investments. These variables are included without any lag because the depositors tend to take into account the current economic situation. In order to tackle *relationship banking* and the fact that depositors and borrowers (residential mortgage, family loans) are two sides of the same coin, we include the log-level of family-loans and the interest rate on loans as controls in the vector $RL_{i,t-1}$. Provided that each

[15] We report results including control bank-specific variables. Results excluding them are available upon request.

bank might offer different types of deposit characterised by different interest rates even for deposits of the same maturity, this might lead to different behaviours depending on the type of deposits. We conduct the analysis distinguishing among short-term and time deposits and guaranteed and non-guaranteed deposits. The focus on categories of deposits allows us to work with an homogeneous aggregate: i.e. changes in the fraction of uninsured saving deposits are not likely to be distorted by shifts between different kind of deposits as may, e.g., be induced by changes in the level of interest rates.

Secondly, we employ a separate system of equations in which we use as a mean for depositor discipline the interest rate paid on deposits ($interest^d_{i,t}$). Whether banks faced "stigma" on the market, on the deposit side they might want to increase the rate in order to attract deposits or, on the other hand, depositors might ask higher compensation for increased risk. We directly estimate the demand-supply function employing Equation (2). Unfortunately, we have no opportunity to obtain the rates offered by the banks to each specific depositor; however, we compute the (implicit) real interest rate paid on each category of deposit by dividing interest expenses for category j to the volume of deposits j at time t. This ratio seems to be an appropriate estimation of interest cost per unit of deposit and has been widely used in the literature as the "implicit interest rate" (Martinez-Peria and Schmukler, 2001; Ungan and Caner, 2008). In order to tackle the fact that the increase in interest rates might be interpreted, as well, as coincident with an increase in bank-risk not reflected in other observed measures (Hellman et al., 1998, 2000), we control for bank-specific dummy and other risk measures (the same set used in Equation 1).

$$\begin{cases} \textbf{Demand}: \Delta interest^d_{i,t} = \alpha + \beta_1 ln(Deposits_{i,t-1}) + \beta_2 interest^d_{i,t-1} + \beta_3 * P_{i,t-1} + \beta_4 interest^P_{i,t-1} + \\ \qquad \beta_5 ln(amount^P_{i,t-1}) + \beta_6 ffr_t + \beta_7 \mathbf{Bank_{i,t-1}} + \beta_\mathbf{8} \mathbf{price^c}_{\mathbf{i,t-1}} + \alpha_\mathbf{i} + \epsilon_\mathbf{i,t} \\ \\ \textbf{Supply}: \Delta interest^d_{i,t} = \alpha + \beta_1 ln(Deposits_{i,t-1}) + \beta_2 interest^d_{i,t-1} + \beta_3 * P_{i,t-1} + \\ \qquad \beta_4 \mathbf{Macro_{i,t}} + \beta_\mathbf{5} \mathbf{RL_{i,t-1}} + \alpha_\mathbf{i} + \epsilon_\mathbf{i,t} \end{cases} \tag{3.2}$$

In both Equation (1) and (2) observing the coefficient estimates for the bank's participation in the liquidity programs β_3 provides the basis for testing market discipline. Generally speaking, we look for statistically significant associations between this variable and its subsequent net deposit flows and deposit rates. All else being equal, weaker banks are described as subject to market discipline if they experience less net growth in deposits or if they pay higher deposit rates. Depositors, that is, are presumed to react to the observed weakness by either (i) channelling money away from weaker institutions or (ii) requiring a deposit rate premium as compensation. The two dependent variables provide a more comprehensive test of market discipline than relying upon just one (Martinez-Peria and Schmukler, 2001).

Information disclosure. In Equations (1) and (2) we conduct the analysis following the hypothesis that depositors, as market participants (Furfine, 2003; Armantier et al., 2015), react one quarter following the access to the facility by the bank; that is, they are able to infer the participation in Federal Reserve's liquidity programs immediately after they borrow, nonetheless the Federal Reserve keep the information private. However, given that the regulation affects all banks, the setting of the unexpected liquidity disclosure enables to construct a counterfactual scenario of the consequences of liquidity disclosure by comparing banks that were directly affected by these disclosures (banks accessing the DW or TAF) with those that were not. Thus, in order to study if liquidity disclosures provide incremental information to the capital market over and above that available in financial filings we investigate depositors' reaction at the day of the information disclosure.[16] Particularly, we repeat previous analysis investigating depositor reaction 2 years following the event for DW borrowers and following December 2010 for TAF borrowers. For Discount Window borrowers we estimate the effects on the growth rate of $deposits_j$ or $interestrate_j$ (whatever the category j we are considering) eight quarters later with respect to the level of deposits in quarter t. For TAF borrowers we estimate the change in log-level of deposits in the first quarter of 2011 (because the information has been released in December 2010) with respect to the previous quarter for all the banks which participated in the facility between 2007 and 2010.

Market share analysis. In order to investigate if previous findings reflect the change in the composition of banks' liability side or a change in the aggregate level of bank's deposits we perform the analysis investigating the effects on the deposit market share.

Using difference in difference (fixed effect) methodology, we model the effect of the decision to participate in the Discount Window and Term Auction Facility on the change in market share. As standard in the literature (Saunders, 1981; Freixas, Parigi and Rochet, 2000), for both deposits and loans, two banks in the same location face the same demand for loans and the same supply of deposits. Thus, we estimate the effect of the participation in Federal Reserve's liquidity programs within the same state[17] in order to capture macro-economic condition faced by two banks in the same area.

$$\begin{aligned}\Delta ln(Mktshare^{I}_{i,j,t}) =& \alpha + \beta_1 ln(Mktshare^{I}_{i,j,t-1}) + \beta_2 \Delta ln(Offices^{I}_{i,j,t-1}) + \beta_3 \Delta ln(Deposits^{I}_{i,j,t-1}) \\ &+ \beta_4 P_{i,t-1} + \beta_5 \mathbf{Macro_t} + \alpha_\mathbf{i} + \alpha_\mathbf{j} + \epsilon_\mathbf{i,j,t}\end{aligned} \tag{3.3}$$

[16] We are aware that, for this kind of research the proper methodology is represented by event-study, however data on deposits are available only on a quarterly-based frequency.

[17] As standard in the literature on commercial bank, we should control for fixed effect Metropolitan Area (MSA) instead of state, however, our analysis at Bank Holding Company level justifies the use of state FE.

$$\Delta ln(Mktshare^{O}_{i,-j,t}) = \alpha + \beta_1 ln(Mktshare^{O}_{i,-j,t-1}) + \beta_2 \Delta ln(Offices^{O}_{i,-j,t-1}) + \beta_3 \Delta ln(Deposits^{O}_{i,-j,t-1}) + \beta_4 P_{i,t-1} + \beta_5 \mathbf{Macro_t} + \alpha_\mathbf{i} + \alpha_\mathbf{j} + \epsilon_{\mathbf{i},-\mathbf{j},\mathbf{t}} \tag{3.4}$$

Where, the state fixed effect α_j controls for common factors that all banks within the same state face, including local economic condition and local demand for loans. We also control for one year of log-lagged market share, and deposit and offices growth to allow for dynamics in the outcome variable. The identification assumption of this strategy is that the sum of market shares (within each state) has to sum 1 and that banks that are in the same state face together the same local demand ($D_{i,t} = D_{m,t}$). By taking differences, we net out these common demand factors that may influence deposits growth and β_4 represents the effects of the participation in the liquidity program $P_{i,t-1} = \{DW; TAF\}$ on the change in market share for bank i.
In Equations (3) and (4), $\Delta Mktshare^{I,O}_{i,t}$ stands for the change in the deposit market share in the same state in which the bank is headquartered $I - Inside-$, and in the sum of the market shares in all the other states but where headquarter are located $O, -Outside-$. In this way we investigate for the presence of herding effects in states different from where the bank conducts its primary business. Provided that banks' usage of the Discount Window or Term Auction Facility was confidential information in the borrowing quarter, we ask whether other market participants were able to identify which banks were asking funds to the Fed and if the reactions among *inside* and *outside* depositors happened in the same year (if any). As analysed before, when uninsured depositors become concerned about the financial conditions of their banks, they have an incentive to use any available information to identify which banks are weak or in proximity to fail. Thus, uninsured depositors in a bank will be looking carefully for signs a silent run has begun on their bank. As before we estimate Equations (3) and (4) one year after the access to the facility and when the information on borrowers' name is effectively disclosed.
Propensity Score Matching. Lastly, we use Propensity Score Matching in order to compare the effects on the change in the deposit market share on two sub-samples of banks: those participating in DW versus those which did not or those participating in the TAF program and those which did not. With this methodology, banks in the control group are those banks having *ex-ante* the same probability to participate in these programs. In particular, given that banks relying on these facilities are those under liquidity distress we compare banks facing difficulties ex-ante and we select banks in the *control sample* as those banks having *ex-ante* the same probability of participating in the Federal Reserve's liquidity facilities.
That is, we estimate to what extent the treatment (participation in the facility, $P_{i,t-1}$) changes the average deposit market share for the BHCs who were actually treated, had they not participated in the facility. The

effect of the participation in the facility on the market share of bank i, can be expressed as:

$$ATT = E\{\Delta ln(Mktshare^{P}_{i,t+1})|P_{i,t} = 1\} - E\{\Delta ln(Mktshare^{NP}_{i,t+1})|P_{i,t} = 1\} \quad (3.5)$$

Where $Mktshare_{i,t+1}$ represents the *Inside (Outside)* market share of deposits and P represents the participation in the Discount Window or Term Auction Facility. I.e. $DW_{i,t}$ is a dummy indicating the participation in the Discount Window facility and taking a value equal to one if bank i participates in quarter t, $\Delta ln(Mktshare^{P}_{i,t+1})$ is the change in *Inside* (*Outside*) market share of bank i at time *t+1* following the participation in year t, and $\Delta ln(Mktshare^{NP}_{i,t+1})$ is the hypothetical performance change of the same bank i in *t+1* had it not participated the previous year. The selection problem is of great concern because there is no direct estimate of the counterfactual mean analogous to the one based on randomisation and PSM allows us to control for selection on observables. Matching methods are useful when no good instruments are available with non-randomized groups and using them is useful if there are many potential controls. In order to verify if the participation decision in these facilities does not affect the distribution of potential outcomes we test whether the common support condition and the conditional independence assumption are satisfied.[18]

The propensity score matching is a two-stages semi-parametric procedure where in the first stage we estimate the probability of being treated (using probit regression) on the basis of pre-treatment observables X. We consider in our set of pre-treatment regressors macroeconomic variables as Federal Fund Rates -*ffr*-, average rate on commercial paper *CP rate*, the Treasury rate, the S&P500, the Bond Index, the Cpi index, GDP growth rate and the Vix. Among the balance sheet accounting controls we consider the logarithm of total assets in order to proxy the size, of loans commitment, interbank debt, repo and commercial paper financing and the level of capitalization. In the second stage, we match treated and untreated with the same p(X), we calculate the differences in outcome and we average it out; the untreated sample is identified by Kernel matching:

$$ATT = \frac{1}{N}\Sigma_{i\in N}\{\Delta y^{1}_{i,t+1} - \Sigma_{j\in C} w_{i,j}\Delta y^{0}_{i,t+1}\} \quad (3.6)$$

3.5 Data

We collect quarterly data from US BHCs filling the FRY-9C from January 2002 to March 2016 and we extend this dataset including information based on the participation in the Discount Window and Term Auction Facility implemented by the Federal Reserve. Initially, the dataset includes 6,104 BHCs for the years under

[18]The common support condition needs that for every bank there is a positive probability of non-participation or, for every treated unit there is another matched untreated with similar X: $0 < Prob[P_{i,t} = 1|X] < 1$; the conditional independence assumption needs that, conditional on covariates, the outcomes are independent from the treated; that is: $F(\Delta y^{j}_{i,t+1}|X, P_{i,t} = 1) = F(\Delta y^{j}_{i,t+1}|X, P_{i,t} = 0) = F(\Delta y^{j}_{i,t+1}|X)$

consideration. However, we narrow it considering only consolidated balance sheets of banks with total assets greater than 500 million of dollars filling the "BHCK" fields.[19] Thus, our final dataset comprises observations for 1635 BHCs from January 2006 to March 2016.[20] The choice of using data on bank holding companies has been employed for two reasons. Firstly, when banks suffering liquidity difficulties are subsidiaries, we make the hypothesis that the bank holding company as the largest bank in the network is the leader in providing aid (just to prevent that subsidiaries borrow at higher rates than those within the banking group). Secondly, since the final aim of the analysis is to investigate the effects on depositors' behaviour following the participation of the bank in the emergency liquidity programs, we think that it is reasonable that the reaction will impact the group.

Concerning data about the programs, the dataset has detailed information for each loan including the borrower, the date in which credit was extended, the interest rate paid, information about the collateral, and other relevant terms. The transaction data are provided from the Federal Reserve in compliance with the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 on a daily basis. For what concern data on Discount Window, they are published quarterly with two years lag from the first quarter of 2010 (thus our dataset contains data up to March 2014). Particularly, the original data comprise information on 11,448 DW operations conducted from July 2010 to March 2014. Their distribution is provided in the Appendix section: among them 8,070 took part in the form of primary credit, 2,836 in the form of seasonal credit and 542 in the form of secondary credit. However, we exclude from the sample credit unions, thrifts and borrower banks which do not belong to bank holding companies (we match banks based on ABA number of commercial banks which are part of BHCs). Provided that 91% of banks asked for funds more than once during each quarter, the dummy variable $DW_{i,t}$ equals one if the BHC participated in the facility at least once in the quarter; thus we collapse daily data by the creation of a dummy variable equals 1 if the bank participated in the DW program in the quarter of analysis and zero otherwise. Once we exclude multiple accesses in the facility we remain with 6,774 borrower-quarter observations (which become 2,927 when we exclude from the analysis banks which are not part of a bank holding company). TAF was active from December, 12th 2007 to March, 8th 2010 and data were release on December 2010 under the Dodd-Frank Act. Banks participated in this facility 4,214 times. Even in this case banks asked for funds more than once during each quarter: collapsing multiple accesses and excluding banks which are not part of a bank holding company, the dummy variable TAF is equal to 1 in 427 cases.

The first stage of the analysis investigates the change between two quarters in the quarterly average of interest bearing deposits -*QDep*- (BHCK3517) which includes the quarterly average for all interest-bearing deposits held in domestic offices of depository institutions that are consolidated subsidiaries of the bank holding company

[19]Beginning March 31, 2006, the FR Y-9C filing threshold was increased from $150 million to $500 million or more and FR Y-9SP filing threshold was increased from $150 million to banks with total consolidated assets of less than $500 million.

[20]We exclude from the analysis financial institutions belonging to Charter type (RSSD9048) of insurance broker or insurance companies (code 550), Employee Stock Ownership Plan (code 610), securities broker or dealer (code 700), utilities company and credit card companies without commercial bank charters (codes 710 and 720).

(this field also includes all time and savings deposits in domestic offices). Then, we investigate the presence of depositor discipline disentangling the log-difference in short-term and time deposits. In the first category we consider liquid deposits -*LiqDep*- (BHCB3187) defined according to the Federal Reserve Board, as the total of all accounts subject to negotiable orders of withdrawal (”now”), all ATS accounts and all other transaction accounts (excluding demand deposits). Then, we consider demand deposits -*DemandDep*- (BHCB2210) which include all checking accounts (including those pledged as collateral for loans and excluding Now accounts). Thirdly, we include also non-interest bearing deposits (BHDM6631) as *NonIntDep*. Fourthly, we consider interest bearing deposit liabilities that reprices within one year or mature within one year as *ShortDep* (BHCK3296). Lastly, all fixed rate and floating rate time deposits of $100,000 or more with a remaining maturity of one year or less -*ShortTimeDepNG*-(BHDMA242). Among time deposits we include the following sub-groups. Firstly, all outstanding time deposits of $100,000 or more, both negotiable and nonnegotiable -*TimeDepNG*- (BHCB2604). Secondly, all time deposits of less than $100,000.[21] Lastly, we consider non transaction saving deposits as *SavDep* (BHCB2389) which includes Money Market Deposit Accounts (MMDA’s). With reference to geographical location we include the amount of total interest bearing deposits in domestic offices (BHDM6636) as *DomDep*.[22] When we conduct the analysis on market share we use the information from the US Summary of Deposits provided by the Federal Deposit Insurance Corporation (FDIC). The Deposit Market Share is the percentage of deposits an FDIC-insured institution has within a defined geographic market as of June 30 of each year. We collect data at state and bank holding company level and we match information from FRY-9C based on RSSD9001 code. We do not collect data at Metropolitan Statistical Area (MSA) level because our aim is to investigate the effects on BHCs, and the analysis at MSA would not have produced high cross-sectional variation. Moreover, roughly 90% of FDIC-insured institutions in each state belongs to a BHC. For each Bank Holding Company we collect information on the state in which headquarters are located (*Inside*) and information for all the US states but where the BHC is headquartered (*Outside*). Information concerns: number of office, amount of deposits and market share. I.e. 97% of FDIC-insured depository institutions in Arizona, as of 30th of June 2015, belong to Bank Holding Companies; among them, Western Alliance Bank (commercial bank) which belongs to Western Alliance Bancorporation (BHC) has 11 offices, $ 3,543,203 th of deposits and a market share of 3.35% in Arizona, whilst 30 offices outside Arizona collecting $ 7,917,256 th of deposits. At the same time, JPMorgan Chase Bank, National Association which belongs to JPMorgan Chase & Co. Bank Holding Company has headquarter based in New York but collects $ 27,530,906 th of deposits in Arizona via 267 offices and representing 26.07% of the market.

[21] This item (BHCH6648) includes all non-transaction time deposits reported in item 2350, with balances of less than $100,000. Also includes both time certificates of deposit and open account time deposits with balances of less than $100,000, regardless of negotiability or transferability.

[22] the Federal Reserve Board definition reports in this category the dollar amount of ”Time Certificates Of Deposit Of $100,000 Or More” held in domestic offices of the reporting bank.

3.6 Results

3.6.1 Summary statistics

This section provides summary statistics for BHC's market shares and kind of deposits.

Table 3.1 shows that banks participating in the Term Auction facility are those with greater business in states different from where they are headquartered. In particular, it shows that, on average, TAF banks cover 34% of the market outside their headquarter boundaries collecting deposits via roughly 522 offices. Whilst, banks participating in the Discount Window program are less present in states different from where their headquarters are located: on average, they represent 3% of the market share outside headquarter boundaries collecting deposits via 62 offices. Concerning the presence in the same state in which they are headquartered we notice that banks participating in the Term Auction Facility program are still those with the greater market share inside the state (roughly 5%) collecting deposits via 124 offices, whilst banks participating in the Discount Window facility represent just 1.6% of the market in which they headquarter are located collecting deposits via 26 offices on average. Thus, we can infer that banks which participated in the Term Auction facility were larger banks with greater business all over US states independently from where they are headquartered. Concerning the geographical location of where deposits are collected and their timing we notice that banks participating in the Term Auction Facility have the larger share both in what concern domestic, short-term and time deposits. However, since we are interested in how depositors react following the participation in the liquidity emergency program, we concentrate our analysis on Table 3.2. Panel A shows depositors reaction for Discount Window borrowers and banks belonging in the control group (that is all the bank holding companies that did not participate in the DW facility between the first quarter of 2010 up to the first quarter of 2014). We notice that the growth rate of the share of deposits collected within the US boundaries is smaller for DW borrowers with respect to the control group and the same happen for the quarterly average of deposits (without distinguish among sub-categories). Concerning short-term deposits, we notice that *Liquid deposits* and *Demand deposits* are increasing at a higher rate for DW borrowers with respect to the control group, whilst *Short-term deposits* are decreasing at a smaller pace with respect to the group. Interestingly, the growth rate of *Non-interest deposits* is lower for bank holding companies participating in the Discount Window program with respect to the control group. In what concerns time deposits we notice that, except from *Saving deposits* which show a positive growth rate for the period which we are considering, all kind of time-deposits are decreasing in the years from 2010 up to 2014. However, distinguishing among bank holding companies participating in the Discount Window facility and banks which did not in the same period Table 3.2 (Panel A) exhibits larger decreasing rate for DW borrower in *Guaranteed* and *Non Guaranteed* time deposits. Moreover, even if *Saving deposits* are showing a positive growth rate, the pace for DW borrowers is smaller than in the control group. Panel B shows results for

bank holding companies participating in the Term Auction Facility program with respect to banks which did not along the same period (2007q3-2010q1). Results show that, provided that deposits are increasing in that period, for all sub-groups of deposits the growth for TAF borrowers is larger than for bank holding companies which did not participate in this facility. Interestingly, whilst *Short-term deposits* which reprice with one year are decreasing in the group they are increasing for banks participating in the Term Auction Facility program.
Concerning market share analysis, Panel A (Table 3.2) shows that banks participating in the Discount Window facility are increasing the number of offices in the state in which they are headquartered however, in the same state, they are increasing at a slower pace the amount of deposits they are collecting losing at the same time their market share within the same state (with respect to the control group for the same period). Interestingly, results do not show the same evidence for deposits collected outside their headquarter boundaries: in particular, even if the growth rate of deposits is smaller than in the control group, their market share is increasing. Concerning results for Term Auction facility participants, Panel B shows that TAF borrowers are increasing the number of offices, the amount of deposits and their market share with respect to the control group in the same state in which headquarter are located (these results are opposite with respect what we found for DW borrowers). Whilst, concerning the market share outside the headquarter borders the pace at which they are collecting deposits is lower with respect to the control group but the market share is growing.
Table 3.3 shows the average cost of deposits for banks which participated in the Discount Window program and banks that did not between 2010 and 2014 (Panel A) and for banks which have participated in the Term Auction facility and banks that did not between 2007 and 2010 (Panel B). Evidence show that, on average, cost of deposits is higher for Discount Window banks than for banks in the control group and this evidence is validated for almost all sub-samples of deposits: cost on domestic deposits, the average cost of deposits and for Non-guaranteed deposits. Interestingly, Panel A shows that the interests paid per unit of Guaranteed deposits is higher than the interests paid per unit of Non Guaranteed deposits and this trend is not confirmed for the banks belonging in the control group in the same period. Panel B shows that banks participating in the Term Auction Facility paid, on average, higher interests on deposits with respect to the control group in the same period. However, for all sub-categories of Domestic, Non guaranteed and Guaranteed deposits banks which participated in the Term Auction Facility had a lower unit cost of deposits.

3.6.2 Depositor reactions

Discount Window. Table 3.4 (Panel A) shows the reaction of short-term depositors one quarter following the bank participation in the Discount Window program. The supply side equation shows no depositors reaction for the categories of demand deposits, average short-term deposits, non interest deposits and liquid deposits;

however, column (5) shows that there is a reduction in the share of non-guaranteed deposits (that reprice within one year) in the quarter following the access to the DW program. Furthermore, Panel B shows that the effect is confirmed and larger when the information is disclosed (the Federal Reserve published information on borrower's name with two years lag) and the negative depositor reactions do not concern only Non-guaranteed short-term deposits but also liquidity deposits which effectively register a negative growth in the quarter following the disclosure of information. Table 3.5 shows the reaction of depositors which invested in time-deposit in the quarter following the one in which the bank participated in the Discount Window (Panel A) and when the information was released (Panel B). Looking at the supply-side equation, results show that time depositors reacted by withdrawing their Non-guaranteed and Saving deposits in the quarter following the access to the facility. However, when the information on borrowers' name is disclosed, the negative reaction is larger: Panel B shows that deposits (on average), domestic deposits and saving deposits decrease by 24 bp. when the information is disclosed and that Non-guaranteed deposits decrease by 43 bp. Interestingly, we notice that Guaranteed deposits do not react neither in the quarter following the access nor when the information is released.

Table 3.6 reports evidence on interest rate per unit of each category of deposits. Panel A shows that, as reported by Calomiris (2006) and Brunnermeier (2009), cost of funds reduces in the quarter following the access to the facility both from the demand-side and from the supply-side. However, 8 quarters following the access to the facility, when the information is released, we notice that banks continue to be willing to pay a lower interest rate, whilst depositors ask for higher interest rates both on guaranteed and non-guaranteed deposits (with a larger risk-premium for non-guaranteed deposits).

Term Auction Facility. For the period 2007-2010 we investigate the presence of depositor reaction following the access to the Term Auction facility; however, results in this section and those in the Discount Window section are not directly comparable because they refer to two different periods. Table 3.10, in Panel A, reports the growth rate of short-term deposits in the quarter following the access to the facility. Evidence shows that, in the quarter following the access to the liquidity program, banks participating in the Term Auction facility reduce their demand for non-interest deposits, liquid deposits and demand deposits; whilst they increase their demand for short-term deposits (on average) and column (5) reports an increase in the share of non-guaranteed short-term deposits: for both categories of deposits the magnitude of the increase is almost the same. Panel B shows results for the change of short-term deposits after December 2010, that is the month in which information was disclosed under the Dodd-Frank Act. Banks which have participated in the Term Auction Facility between the fourth quarter of 2007 up to the first quarter of 2010, show in the second quarter of 2010 (or after) an increase in demand-deposits and non-guaranteed short-term deposits. Table 3.11 shows the results on the growth rate of time deposits in the quarter following the participation to the Term Auction Facility (Panel A) and after the information disclosure (Panel B). Panel A shows that, except from saving deposits, time-depositors react by lending more money in the quarter following the access to the facility whilst, in the quarter following the information release, banks still continue to demand more deposits, but the positive growth rate on depositors' side is associated only to non-guaranteed and guaranteed deposits. In particular, although the smaller magnitude for both kind of deposits, the positive sensitivity is larger for guaranteed deposits than for non-guaranteed ones. Table 3.12 shows the effects on cost of deposits. Panel A, shows that banks are willing to pay higher interest rates one quarter after the participation in the Term Auction Facility program on the gross amount of deposits, on domestic deposits, guaranteed and non-guaranteed ones and, on the supply side, this evidence is confirmed by the fact that depositors are requiring higher compensation for domestic deposits and non guaranteed deposits. Interestingly, and in line with a stronger market discipline, the higher risk premium is required by non-guaranteed depositors. Results from Panel B show that depositor discipline in the form of higher interest rates is confirmed in the quarters following the information disclosure even if the effect is smaller in magnitude.

3.6.3 Effects on market share

Discount Window. Table 3.7 reports results from the fixed effect regression. Panel A shows the effect on the growth rate of the deposit market share in the same state in which the bank holding company is headquartered. Results show that banks participating in the Discount Window program show a reduction in their deposit market share in the year following the participation in the facility and the effect persists in the next three years. Moreover, our evidence shows that the worst reduction in the deposit market share happens following 2 years which is exactly the same lag with which information on borrowers' name is released. Panel B excludes the presence of depositor discipline in states different from the one in which the borrowing bank is headquartered. Actually, Panel B shows that not only we should exclude the presence of herding effect among depositors of Discount Window borrowers, but also that these banks increase their market share of deposits in the second and the third year following the participation in the emergency lending program. Table 3.8 reports results on market share analysis for Discount Window borrowers distinguishing among Listed and no-Listed banks. Evidence, both in Panel A and Panel B, exhibits that the decrease in deposit market share for Discount Window borrower is not mainly motivated by the fact that the bank is traded on the stock exchange (Cyree, 2013). In particular, the negative effect on deposit market share in the same state in which the bank is headquartered persists along two years after the borrowing, whilst there are no effects on the market share outside the state in which the bank has headquarters. In Table 3.9 we report results from Kernel Matching estimation following PSM. Evidence shows that, selecting bank which have ex-ante the same probability to participate in the Discount Window, the deposit market share of borrowers from DW reduces in the year(s) following the participation in the emergency liquidity program, and the decrease is larger in the second year with a reduction in the market share by roughly 2%. Panel B shows that results hold when we control for the logarithm of the number of offices and log of deposits in the state in which the borrower bank is headquartered. Moreover, when we investigate for the presence of herding effects in states different from the one in which the bank has the headquarter, evidence shows that banks participating in the Discount Window increase their market share in the three years following the participation (although the mild effect).

Term Auction Facility. Tables 3.13 and 3.14 report the market share analysis for banks which have participated in the Term Auction Facility between the fourth quarter of 2007 and the second quarter of 2010. Results from columns (1), (2) and (3) of Panel A show that banks which relied on Term Auction Facility in order to solve liquidity needs, experienced an increase in their deposits market share and the effect is larger over time. On the other hand, Panel B excludes the presence of herding effects not showing changes in the market share of deposits in the states in which the bank is not headquartered. Interestingly, Table 3.14 shows that the positive reaction on deposit market share is mainly driven by listed TAF borrowers both on the market share in the same state in which the bank has headquarters and outside it. Table 3.15, controlling for observable bank-specific characteristics, shows that the market share of deposits in the same state in which the borrower is headquartered and in the other states increases following the access to the facility: however, the change is larger in the year following the information disclosure.

3.6.4 A comparison in 2010.

Although we cannot compare directly the effects on depositors' behaviour between the two programs because they refer to two different periods[23], we assume that in 2010 the surrounding economy is the same and we carry out the analysis considering only quarters in 2010. Particularly, Table 3.16 (Panel A) shows results from structural equation analysis on representative categories of deposits: domestic, non-guaranteed and guaranteed deposits. Results show that banks borrowing from TAF encourage gathering of deposits whilst this evidence is not confirmed for banks asking funds from Discount Window. Concerning depositors' behaviour, Panel A -in the Supply equation- shows that savers deposit more in banks which have participated in the Term Auction Facility and they direct their funds especially towards Non-guaranteed deposits (and results are confirmed for domestic deposits equation). Depositors of banks which have participated in the Discount Window facility discipline their banks by withdrawing their Non-guaranteed deposits. Interestingly, comparison in 2010, exhibits that depositors from Guaranteed deposits neither discipline Discount Window banks, nor increase their deposit in

[23] Data on Term Auction Facility refer to the period 2007q4-2010q2 whilst data on Discount Window refer to 2010q2-2014-q1.

banks which have participated in the Term Auction Facility. The lack of evidence on this category could be read in conjunction with changes in Deposit Guarantee Schemes along that quarters.[24]

Panel B reports results on interests per unit of deposits. The supply-side equation shows that depositors of Discount Window borrowers discipline their banks in 2010 by requiring higher interests both on Guaranteed and Non-Guaranteed deposits (whilst along the period 2010-2014 they discipline banks when the information is disclosed). Depositors of TAF borrowers, despite increase their non-guaranteed deposits they do not require a compensation on interests (different from previous fundings); in fact, on average, cost of deposits decreases for TAF banks.

3.7 Concluding remarks

This chapter analyses the problem of the liquidity crisis from different points of view. Before the financial crisis banks increasingly relied on the interbank market to manage their liquidity needs in the short-run; however, during the crisis, the losses on MBS and the lack of confidence among financial intermediaries led them to withdraw resources deposited with other institutions generating a liquidity crisis (and forcing banks to borrow in the markets at higher rates). In order to fill the gap, restore the market for funds, avoiding bank-runs and avoid to transform situations of temporary liquidity shortages into insolvent banks, several regulatory proposals have been put forward with the aim of preventing domino effects and bail-out conditions.

With this respect, we analyse two important programs proposed by Federal Reserve: Discount Window and Term Auction Facility. Initially these programs have included not to reveal the identity of the borrower but, following The Dodd Frank Act for TAF and admonition of Bloomberg for DW, the Federal Reserve released the name, quantity and rates paid by the banks for the two programs. TAF information was released in December 2010 for all loans while for DW information was made public quarterly, with two years of delay starting from 2010. Despite Federal Reserve's attempts to hide the names of the participants for fear of negative reactions on the markets, different papers (Furfine, 2003; Armantier et al, 2015) demonstrate the presence of "stigma" associated to DW. I.e., banks participating in this program were perceived as not-financially stable with negative market effects. Furthermore, TAF, was born precisely to meet the weakness of DW. Motivated by the fact that the recent crisis has shown again the threat of bank-runs, this chapter investigates the presence of reaction by depositors when banks participated in Fed's emergency liquidity programs and when information has been released.

Using 3SLS structural equations in order to take into account the demand and supply effects, results show that

[24] On 3rd October 2010, the FDIC Temporary Liquidity Guarantee Program extended the deposit guarantee from 100.000$ to 250.000$ up to 31st December 2010; however, on the 20th May 2009, given the difficulties faced by the US economy, the FDIC extended the guarantee up to 31st December 2013 but with the Dodd-Frank Act this decision became permanent (21st July 2010). These changes in the deposit guarantee schemes deserve further investigation and they are analysed in the following section.

depositors of DW-banks effectively discipline their banks: in the quarter following the access to the facility the share of non-guaranteed and saving deposit diminishes and the effect is even larger when information on borrower's name has been released (eight quarters later). In general, the share of deposits which suffers more DW-stigma concerns time deposits. In the quarter in which information is released the share of domestic and saving deposits decreases by roughly 23 bps., whilst the share of non-guaranteed deposits decreases by about 40 basis points. The only sub-category of deposits which does not register neither an increase nor a decrease are guaranteed-deposits. Furthermore, depositors may discipline banks taking part in the Discount Window program also via interest rates. Our evidence shows that the unit-cost of deposits decreases for guaranteed and domestic deposits one quarter following the access to the facility (while no changes are shown for the unit-cost of non-guaranteed deposits). Eight quarters later, when information on borrowers' name is published, depositors discipline their banks by requiring a risk-premium on guaranteed and non-guaranteed deposits (penalising more the non-guaranteed ones, as expected).

Using the same methodology, we analyse the behaviour of depositors of banks participating in the Term Auction Facility between 2007 and 2010. Among short-term deposits, our evidence shows that quarterly average of short-term deposits and non-guaranteed deposits that reprice within one year, increase in the quarter following the access to the facility (while when the information is disclosed the effect is still there but very mild in magnitude). All time deposits show a positive reaction following the bank access to the Term Auction liquidity program. As for short-term deposits the reaction is stronger in the quarter following the participation in the program: the effect persists for non-guaranteed and guaranteed deposits when the information is disclosed (in December 2010). However, even if depositors of TAF borrowers do not discipline their banks via quantities they do it via prices: unit-cost of domestic and non-guaranteed deposits increases following the access to the facility and persists when the information is disclosed, whilst there is no reaction on price of guaranteed deposits.

In the second phase of the analysis, using yearly data from the US Summary of Deposits provided by the FDIC, we check whether the results of the previous analysis remain, focusing on the change in the market share (in terms of deposits). We compare the results on the change in market-share, one and two years after the access to the facility, in the same state where the bank is headquartered and in the others. Using Fixed Effect regression and Propensity Score Matching (in order to control for bank observable characteristics *ex-ante*), our evidence shows that Discount Window borrowers reduce their market share in the state in which they are headquartered and, although the immediate effect, the market share suffers the larger losses in the year in which the information is disclosed. Nonetheless, results on bank's market share in other states but where the bank is headquartered, show no reduction in the year in which the BHC accesses the facility and an increase in the following years. These results exclude the hypothesis of herding effects (results are confirmed from PSM when we control for selection on observables). When we conduct the market share analysis on banks which have participated into the Term Auction Facility program (from 2007 up to 2010), results exhibit that the market share increases in the year following the access to the facility and the magnitude becomes stronger overtime. However, evidence from Propensity Score Matching show the presence of "herding effect" with the increase happening also in the states in which the bank is not headquartered and with mild effect when the information on borrowers' name is disclosed.

3.8 Graphs and Figures

Figure 3.3: Growth rate of wholesale funding

This graph shows, the growth rate of wholesale funding for the bank holding companies in our dataset. The time period reported in the graph is longer than the one considered in the analysis in order to evidence how banks relied strongly on the interbank market before the financial crisis. The variable of interest is the net exposure of the borrowed money from other commercial bank in the US (RSSD BHCK3190), the net balances due from US banks (RSSD BHCK5993), foreign banks and central banks (RSSD BHCK0395). The growth rate is computed as the log-difference of the variable with respect to the previous quarter.

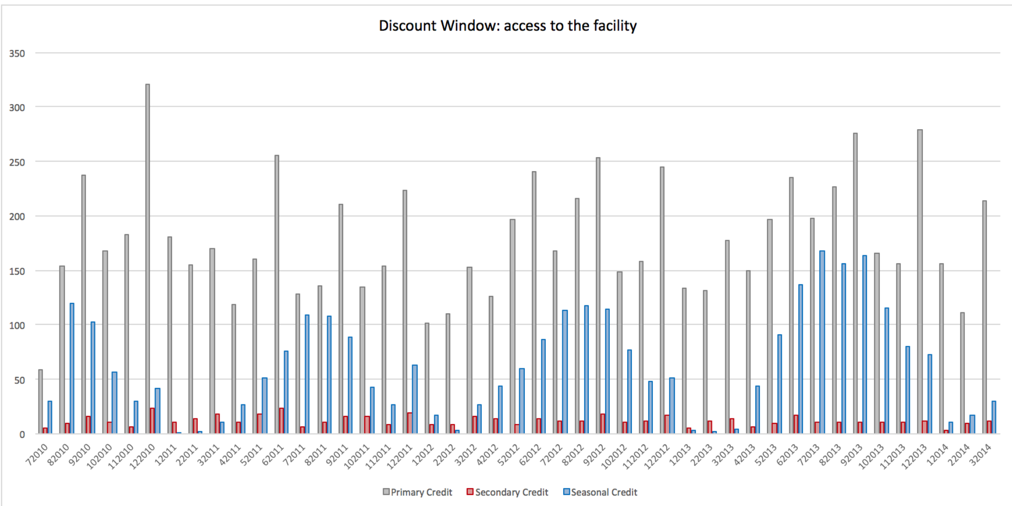


Figure 3.4: Access to DW

This figure reports the access by bank holding companies in our sample to the three Federal Reserve Bank's main lending programs along the period in which public information is available. The grey and the red bars indicate the access to the Primary and the Secondary credit programs respectively, whilst the blu bar indicates access to the Seasonal facility addressed to depository institutions to meet their communities' peak seasonal funding requirements (but which lack access to national money markets). Each bar indicates the number of access to the facility by banks in our sample per quarter. Multiple access in the same day are considered just once.

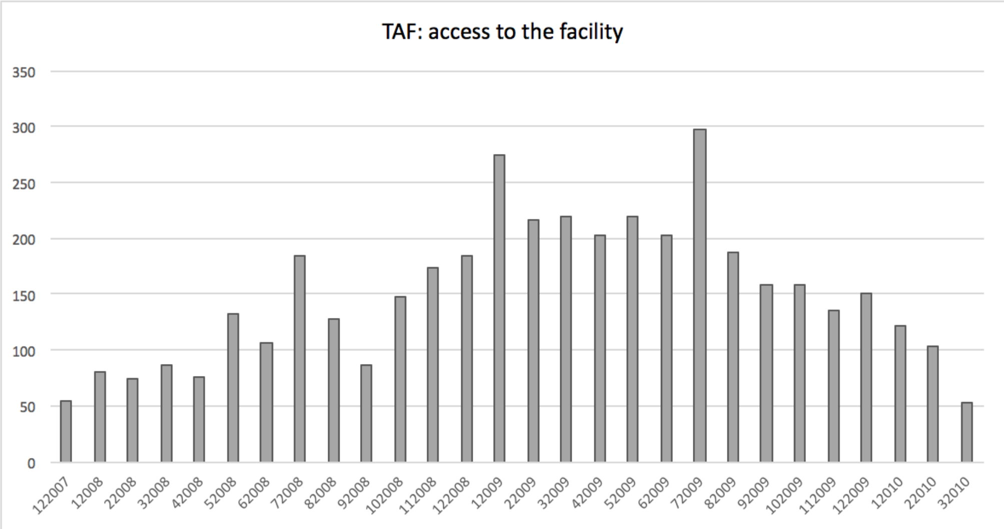


Figure 3.5: Access to TAF

This figure reports the access by bank holding companies in our sample to the Federal Reserve Bank's Term Auction Facility program. Each bar indicates the number of accesses to the facility by banks in our sample per quarter. Multiple access in the same day are considered just once.

3.9 Tables

Table 3.1: Summary statistics: deposit categories (log-level) and market share

This table reports summary statistics for different categories of deposits included in three classes: short-term deposits (demand, short-term, non-interest and liquid deposits), long-term deposits (distinguishing among saving deposits, guaranteed and no-guaranteed time deposits) and others (domestic deposits and quarterly-average of deposits). We take the logarithm of all the variables and we report their Mean, Standard Deviation, Min and Max. The last six rows of each panel provide summary statistics for the variables included in the market share analysis: the average number of offices in the state in which bank's headquarters are located and in the states outside, the average of log-deposits collected in the state in which headquarters are located and outside it, and the deposit market share (expressed as percentage) in the state in which bank's headquarters are located and outside it. The first panel provides data for the whole sample excluding banks participating in the DW or TAF programs, the second and the third panel report summary statistics for the sample of banks participating in the Discount Window and Term Auction Facility respectively.

Variable	Obs	Mean	Std. Dev.	Min	Max
Whole sample					
Domestic Dep.	74079	13.2568	1.3328	3.6636	20.4915
Quarterly dep. (avg)	74092	13.2654	1.3430	2.8904	20.4701
Demand dep.	73803	11.1234	1.4513	0.6931	19.9051
Short-term dep.	72508	12.2851	1.4099	2.1972	20.1135
Non-interest dep.	74119	11.4395	1.5339	1.3863	19.9051
Liquid dep.	72835	10.5605	1.3934	0.0000	18.7116
ST NG	73254	11.1579	1.4431	4.6052	18.8038
Time Dep. NG	73580	11.5135	1.3939	4.6052	18.8134
Time Dep. G	73500	11.7972	1.3005	2.9957	18.5368
Saving dep.	73656	12.3366	1.6341	1.7918	20.6709
Offices Out.	13775	101.8456	509.2278	1	6034
Dep. Out.	13673	12.6675	2.2582	1.3863	20.7856
Mkt Share Out.	13775	0.0639	0.3517	0	4.7469
Offices Ins.	42753	27.1909	56.8037	1	1211
Dep. Ins.	42726	13.5497	1.1172	8.2354	20.1011
Mkt Share Ins.	42753	0.0139	0.0348	0	0.4922
Discount Window					
Domestic Dep.	1537	13.7344	1.1763	10.6066	19.0617
Quarterly dep. (avg)	1537	13.7690	1.1754	10.4623	19.0586
Demand dep.	1526	11.5606	1.3990	3.6376	18.1407
Short-term dep.	1518	12.5254	1.2453	3.2189	18.7788
Non-interest dep.	1530	12.0049	1.3942	4.9345	18.2585
Liquid dep.	1511	10.9849	1.4715	4.9127	17.6468
ST NG	1529	11.4030	1.1988	5.2149	17.5906
Time Dep. NG	1524	11.8441	1.1446	5.7170	17.5911
Time Dep. G	1524	12.0001	1.1939	4.8363	16.7980
Saving dep.	1535	13.0541	1.3833	8.8619	19.0275
Offices Out.	531	62.8136	271.2914	1	3000
Dep. Out.	527	12.9781	2.0627	1.386294	19.02027
Mkt Share Out.	531	0.0324	0.1374	0	1.6195
Offices Ins.	1435	26.4641	38.8911	1	430
Dep. Ins.	1433	13.7597	1.0171	10.54897	18.37732
Mkt Share Ins.	1435	0.0163	0.0431	0	0.4092
Term Auction Facility					
Domestic Dep.	323	15.2915	2.0186	11.7723	20.3041
Quarterly dep. (avg)	323	15.2863	2.0310	10.5210	20.2854
Demand dep.	321	12.7445	2.2091	4.1431	18.4238
Short-term dep.	319	14.4486	2.1833	6.6026	20.1251
Non-interest dep.	323	13.4496	2.4483	3.8918	19.3103
Liquid dep.	321	11.9581	1.8812	8.6817	16.8693
ST NG	315	13.4045	2.0538	9.5577	18.8362
Time Dep. NG	320	13.6075	2.0130	10.1583	18.8680
Time Dep. G	323	13.8622	1.9603	9.5780	18.6065
Saving dep.	322	14.6480	2.2694	9.0285	20.0859
Offices Out.	200	522.6300	1143.6820	1	6034
Dep. Out.	200	14.7815	2.7340	8.8320	20.5292
Mkt Share Out.	200	0.3436	0.8067	0	4.2527
Offices Ins.	300	124.5867	193.0566	1	1211
Dep. Ins.	300	14.9660	1.6622	10.4719	19.4204
Mkt Share Ins.	300	0.0536	0.0707	0.0001	0.3436

Table 3.2: Summary statistics: growth rates of deposits and changes in market shares

This table reports summary statistics for different categories of deposits included in three classes: short-term deposits (demand, short-term, non-interest and liquid deposits), long-term deposits (distinguishing among saving deposits, guaranteed and no-guaranteed time deposits) and others (domestic deposits and quarterly-average of deposits). We report the growth rate as the difference of the logarithm between two subsequent quarters. We report Mean, Standard Deviation, Min and Max. The last six rows of each panel provide summary statistics for the variables included in the market share analysis, where the growth rate is computed as the difference between two subsequent quarters. The variables included in the market share analysis are: the average number of offices in the state in which bank's headquarters are located and in the states outside, the average of log-deposits collected in the state in which headquarters are located and outside it, and the deposit market share (expressed as percentage) in the state in which bank's headquarters are located and outside it. The control sample for the first panel is made up by all banks which have not participated in the Discount Window program during the quarters in which information was released; whilst, the control sample for the second panel is made up by all banks which have not participated in the Term Auction Facility during the quarters in which the program was active.

Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
	Discount Window					**Control sample: 2010q1-2014q1**				
Domestic Dep.	1522	0.0047	0.0585	-0.3000	0.7513	20050	0.0059	0.0813	-3.2426	3.0817
Quarterly dep. (avg)	1522	0.0060	0.0923	-0.3029	2.0393	20050	0.0079	0.1081	-1.9859	5.5962
Demand dep.	1510	0.0497	0.3815	-7.4380	2.8639	19990	0.0421	0.3273	-9.1182	9.0378
Short-term dep.	1501	-0.0180	0.1561	-1.7102	2.2689	19692	-0.0204	0.3525	-7.3717	7.3922
Non-interest dep.	1514	0.0292	0.1831	-2.5809	1.1959	20046	0.0303	0.2073	-4.3631	3.7736
Liquid dep.	1494	0.0609	0.4688	-3.1910	9.5816	19647	0.0282	0.4138	-7.3744	10.5513
ST NG	1512	-0.0233	0.2766	-3.9420	6.3699	19775	-0.0200	0.2465	-6.8171	7.1688
Time Dep. NG	1509	-0.0119	0.2050	-1.2287	6.7286	19954	-0.0103	0.1578	-4.6205	6.1269
Time Dep. G	1509	-0.0350	0.1658	-5.2311	0.6735	19944	-0.0237	0.1501	-4.5727	6.0626
Saving dep.	1520	0.0102	0.1399	-1.3149	1.6952	19983	0.0158	0.1385	-2.9504	2.7926
Offices Out.	525	0.1410	5.3620	-45	92	5998	0.0824	12.3163	-310	434
Dep. Out.	521	0.0199	0.1107	-0.4341	1.1354	5948	0.0221	0.2679	-4.7106	11.6189
Mkt Share Out.	525	0.0002	0.0036	-0.0225	0.0473	5998	0.0001	0.0133	-0.4071	0.3114
Offices Ins.	1419	0.0902	1.7244	-10	35	16961	0.0565	2.5554	-139	114
Dep. Ins.	1417	0.0056	0.0597	-0.8391	0.8620	16943	0.0102	0.0871	-2.5404	4.9041
Mkt Share Ins.	1419	-0.0001	0.0012	-0.0271	0.0130	16961	0.0001	0.0026	-0.0419	0.1971
	Term Auction Facility					**Control sample: 2007q3-2010q2**				
Domestic Dep.	320	0.0417	0.1708	-0.1448	1.9140	15429	0.0139	0.0982	-1.9737	3.3076
Quarterly dep. (avg)	320	0.0359	0.2223	-0.7804	3.6085	15431	0.0160	0.1285	-6.9040	7.0213
Demand dep.	317	0.0340	0.3103	-0.7993	3.3461	15402	0.0052	0.3239	-9.1182	6.9798
Short-term dep.	314	0.0022	0.1918	-0.5402	1.7776	15044	0.0004	0.4794	-7.3854	7.4799
Non-interest dep.	320	0.0557	0.4228	-0.8147	6.6564	15436	0.0132	0.2286	-5.8567	5.0839
Liquid dep.	317	0.0685	0.4397	-2.8161	3.7044	15204	0.0106	0.4162	-10.5191	10.5513
ST NG	309	0.0293	0.4618	-0.9754	7.2211	15321	-0.0049	0.3049	-9.7857	6.8854
Time Dep. NG	317	0.0331	0.2015	-0.4713	1.5795	15337	0.0042	0.2197	-9.7894	4.8371
Time Dep. G	320	0.0308	0.3500	-2.5670	3.2501	15334	0.0088	0.2104	-4.5727	6.3193
Saving dep.	318	0.0605	0.2681	-0.7512	3.0822	15363	0.0204	0.1436	-2.9880	3.3394
Offices Out.	197	26.2183	263.6106	-152	3214	4791	1.3565	25.8578	-195	1366
Dep. Out.	197	0.0398	0.1538	-0.2668	1.2239	4754	0.0415	0.2802	-2.8450	6.9829
Mkt Share Out.	197	0.0138	0.1529	-0.1032	2.1038	4791	0.0005	0.0198	-0.5636	0.8480
Offices Ins.	298	2.2081	19.3945	-25	203	14108	0.1875	4.5557	-242	253
Dep. Ins.	298	0.0276	0.1022	-0.1430	1.1182	14101	0.0154	0.0861	-4.0520	1.2500
Mkt Share Ins.	298	0.0009	0.0102	-0.0256	0.1503	14108	0.0001	0.0025	-0.1397	0.1020

Table 3.3: Average interest rate per unit of deposits

	Discount Window					**Control sample**				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Domestic	1537	0.0015	0.0013	0.0000	0.0099	20448	0.0014	0.0014	0.0000	0.0602
Average cost of dep.	1538	0.0086	0.0096	0.0003	0.0924	20495	0.0080	0.0091	0.0000	0.1012
Non guaranteed	1538	0.0109	0.0190	0.0000	0.1905	20495	0.0098	0.0169	-0.0124	0.1905
Guaranteed	1538	0.0117	0.0174	0.0000	0.1660	20495	0.0103	0.0155	-0.0240	0.1660
	Term Auction Facility					**Control sample**				
Domestic	323	0.0035	0.0031	0.0000	0.0219	15681	0.0040	0.0037	0.0000	0.0497
Average cost of dep.	323	0.0205	0.0154	0.0016	0.0735	15702	0.0206	0.0142	0.0002	0.1012
Non guaranteed	320	0.0204	0.0170	0.0016	0.1191	15702	0.0232	0.0219	0.0000	0.1905
Guaranteed	323	0.0197	0.0132	0.0012	0.1203	15702	0.0227	0.0181	0.0000	0.1660

Table 3.4: Discount Window: short-term deposits

	(1) Demand dep. b/se	(2) ST dep. b/se	(3) Non interest dep. b/se	(4) Liquid dep. b/se	(5) ST Non guaranteed dep. b/se
Panel A					
Contemporaneous effect: 1 quarter					
Demand					
$ln(Deposits_{j,t-1})$	.9471***	.9040***	1.0731***	.9006***	.9206***
	(.0783)	(.0428)	(.0724)	(.0520)	(.0409)
DW	.0476	-.1245**	.0114	.1612*	.0301
	(.0779)	(.0605)	(.0859)	(.0904)	(.0674)
interest rate	.0932	.3094*	2.3745***	-1.0224	.1000
	(.3166)	(.1619)	(.5240)	(1.5079)	(2.1957)
Controls	Yes	Yes	Yes	Yes	Yes
Supply					
$ln(Deposits_{t-1})$	1.0086***	1.0285***	1.0152***	.9934***	.9921***
	(.0287)	(.0163)	(.0255)	(.0379)	(.0157)
DW	.0628	-.0399	-.0619	-.0948	-.2206**
	(.1206)	(.0657)	(.1218)	(.1265)	(.1001)
interest rate	.2316	.4783***	1.8567***	3.0804***	1.7209
	(.1645)	(.0782)	(.1390)	(.9660)	(1.6482)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	971	975	974	974	964
R^2	.9454	.9859	.9306	.9224	.9659
log(likelihood)	1055.4197	1168.5369	762.4263	-151.0002	860.6070
Panel B					
Information disclosure: 8 quarters					
Demand					
$ln(Deposits_{t-1})$	.5087***	.7743***	1.1835***	.6352***	.6488***
	(.1381)	(.0749)	(.1819)	(.0847)	(.0966)
DW	.3451	.2139	-.2325	1.0112***	.7436***
	(.2184)	(.1424)	(.1751)	(.2439)	(.2232)
interest rate	-.2735	-.5289	.8905	-1.0788	-2.8759***
	(.6279)	(.3406)	(.5020)	(.7512)	(.5959)
Controls	Yes	Yes	Yes	Yes	Yes
Supply					
$ln(Deposits_{t-1})$	.9898***	.9714***	.9810***	1.0435***	.8486***
	(.0308)	(.0211)	(.0183)	(.0731)	(.0324)
DW	.0533	-.1642	-.0212	-.4904*	-.4469***
	(.1840)	(.1100)	(.1009)	(.2516)	(.1381)
interest rate	.1033	2.2918	-2.8783	1.8945***	.5322**
	(.3586)	(1.9564)	(2.0015)	(.4406)	(.2296)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	871	877	872	873	874
R^2	.8631	.9442	.9546	.7811	.8546
log(likelihood)	-1.25e+03	-172.7328	156.5262	-1.87e+03	-1.29e+03

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.5: Discount Window: time deposits

	(1) Avg deposits b/se	(2) Domestic dep. b/se	(3) Time dep. NG b/se	(4) Time dep. G b/se	(5) Saving dep. b/se
			Panel A Contemporaneous effect: 1 quarter		
Demand					
$ln(Deposit_{t-1})$	1.5709***	1.0418***	.9600***	1.0087***	1.0615***
	(.2701)	(.0476)	(.0253)	(.0689)	(.0720)
DW	.0896	-.0304	-.0937**	-.1453	-.0622
	(.1014)	(.0202)	(.0374)	(.1049)	(.0452)
interest rate	2.7086***	.7743***	-1.9155	.4472*	2.8829***
	(.9101)	(.1285)	(1.1947)	(.2484)	(.9527)
Supply					
$ln(Deposit_{t-1})$	1.0197***	1.0114***	.9973***	.9912***	.9959***
	(.0180)	(.0080)	(.0111)	(.0305)	(.0065)
DW	-.0636	-.0159	-.0995*	.1663	-.0856**
	(.0718)	(.0319)	(.0556)	(.1072)	(.0437)
interest rate	.8512***	.7015***	.6243	.4218***	2.6854***
	(.0920)	(.0445)	(.9011)	(.1389)	(.3652)
Observations	980	980	977	980	978
R^2	.9011	.9947	.9878	.9483	.9916
log(likelihood)	327.4554	3824.4246	1895.8043	1197.0447	2437.3887
			Panel B Information disclosure: 8 quarters		
Demand					
$ln(Deposit_{t-1})$	.9558***	.8414***	.7425***	1.0950***	.7849***
	(.1382)	(.1446)	(.0707)	(.1120)	(.1255)
DW	.4002***	.3737***	.3461**	-.2466	.1873*
	(.0769)	(.0708)	(.1418)	(.2258)	(.1118)
interest rate	-1.0436***	-1.0111***	-1.8730***	-1.1612***	-.8168**
	(.2578)	(.2342)	(.4393)	(.4464)	(.3382)
Supply					
$ln(Deposit_{t-1})$	.9907***	.9967***	.9108***	.9256***	1.0069***
	(.0128)	(.0121)	(.0283)	(.0495)	(.0125)
DW	-.2367***	-.2432***	-.4063***	.2413	-.2423***
	(.0629)	(.0593)	(.1148)	(.2099)	(.0812)
interest rate	3.5253***	3.2460***	2.8145	-2.0403***	1.5551
	(1.1260)	(1.0648)	(1.8976)	(.3813)	(1.5339)
Observations	880	880	880	880	880
R^2	.9786	.9819	.9131	.8117	.9756
log(likelihood)	192.9866	317.7431	-767.0582	-672.8059	158.7148

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.6: Discount Window: cost of deposits

	(1) Interest on Domestic dep. b/se	(2) Quarterly avg cost of dep. b/se	(3) Interest on NG dep. b/se	(4) Interest on G dep. b/se
		Panel A Contemporaneous effect: 1 quarter		
Demand				
$ln(Interest_{t-1})$	-.2924***	.0006	-.2184**	-.0934
	(.0465)	(.0010)	(.0980)	(.0958)
$ln(Deposits_{t-1})$	-.0006**	-.0044	.0031**	.0026*
	(.0003)	(.0048)	(.0014)	(.0015)
DW	-.0018***	-.0103***	-.0144***	-.0092***
	(.0003)	(.0015)	(.0030)	(.0028)
Controls	Yes	Yes	Yes	Yes
Supply				
$ln(Interest_{t-1})$	-.4156***	.0025***	-.3198***	-.0727
	(.0574)	(.0002)	(.1152)	(.1019)
$ln(Deposits_{t-1})$	.0002**	-.0001	-.0024***	-.0008
	(.0001)	(.0007)	(.0008)	(.0007)
DW	-.0011***	-.0020	-.0053	-.0082**
	(.0004)	(.0028)	(.0035)	(.0034)
Controls	Yes	Yes	Yes	Yes
Observations	980	981	978	981
R^2	.2393	.4809	.0843	.1153
log(likelihood)	1.15e+04	7479.8594	6865.0834	7643.0062
		Panel B Information disclosure: 8 quarters		
Demand				
$ln(Interest_{t-1})$	-.0043	.1715***	-.1672*	-.0630
	(.0278)	(.0289)	(.0991)	(.0812)
$ln(Deposits_{t-1})$	-.0005	-.0007	-.0000	.0018
	(.0005)	(.0035)	(.0013)	(.0015)
DW	-.0011***	-.0046***	-.0084***	-.0066**
	(.0002)	(.0014)	(.0030)	(.0029)
Controls	Yes	Yes	Yes	Yes
Supply				
$ln(Interest_{t-1})$	-.0354	.1713***	-.2870**	-.1391
	(.0333)	(.0302)	(.1154)	(.0900)
$ln(Deposits_{t-1})$	.0000	.0002	-.0007	-.0009
	(.0000)	(.0004)	(.0009)	(.0006)
DW	.0003	.0051***	.0081***	.0051*
	(.0002)	(.0019)	(.0030)	(.0030)
Controls	Yes	Yes	Yes	Yes
Observations	880	883	883	883
R^2	.1705	.2872	.0132	.0612
log(likelihood)	1.11e+04	7741.6556	6805.3522	6821.7036

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.7: Discount Window: market share analysis –FE–

	Panel A		
	(1)	(2)	(3)
	$\Delta MktShare^{I}_{t;t+1}$	$\Delta MktShare^{I}_{t;t+2}$	$\Delta MktShare^{I}_{t;t+3}$
	b/se	b/se	b/se
$Office^{I}_{t-1}$	.0136***	.0135***	.0130***
	(.0040)	(.0041)	(.0041)
$Deposit^{I}_{t-1}$	.7516***	.6759***	.6845***
	(.2295)	(.2195)	(.2319)
DW_{t-1}	-.0103**	-.0170***	-.0157**
	(.0042)	(.0051)	(.0070)
$BondI._{t}$	-.0498	-.0164	-.1362*
	(.0445)	(.0760)	(.0818)
$S\&P_t$	.0293***	-.0131	-.0297
	(.0110)	(.0353)	(.0339)
VIX_t	-.0449	.0292	.0064
	(.0302)	(.0355)	(.0359)
GDP_t	-.0023*	-.0036**	-.0017
	(.0012)	(.0015)	(.0018)
DFA	.0100***	.0131**	.0159*
	(.0034)	(.0061)	(.0090)
Constant	-.0074**	-.0004	.0053
	(.0036)	(.0042)	(.0059)
Bank FE	Yes	Yes	Yes
Observations	40662	38045	35449
No. of groups	2354	2341	2301
F-test	7.9134***	9.9473***	6.7051***

	Panel B		
	(1)	(2)	(3)
	$\Delta MktShare^{O}_{t;t+1}$	$\Delta MktShare^{O}_{t;t+2}$	$\Delta MktShare^{O}_{t;t+3}$
	b/se	b/se	b/se
$Office^{O}_{t-1}$	-.0000***	-.0000***	.0005***
	(.0000)	(.0000)	(.0001)
$Deposit^{O}_{t-1}$	.0080**	.0077**	.0078**
	(.0036)	(.0037)	(.0037)
DW_{t-1}	.0004	.0013*	.0017**
	(.0004)	(.0007)	(.0008)
$BondI._{t}$	.0127**	.0213**	.0291***
	(.0056)	(.0099)	(.0092)
$S\&P_t$	-.0000	-.0154	-.0138
	(.0008)	(.0138)	(.0135)
VIX_t	-.0010	-.0003	-.0003
	(.0007)	(.0013)	(.0015)
GDP_t	-.0002	-.0004	-.0006
	(.0002)	(.0005)	(.0005)
DFA	-.0004	-.0006	-.0002
	(.0004)	(.0007)	(.0011)
Constant	.0004**	.0014**	.0012**
	(.0002)	(.0006)	(.0005)
Bank FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Observations	12616	11992	11992
No. of groups	591	586	586
F-test	84.8213***	76.2939***	11.3790***

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.8: Discount Window: market share inside

	Panel A		
	(1)	(2)	(3)
	$\Delta MktShare^{I}_{t;t+1}$	$\Delta MktShare^{I}_{t;t+2}$	$\Delta MktShare^{I}_{t;t+3}$
	b/se	b/se	b/se
$ln(MktShare^{I}_{t-1})$	-.0470***	-.0950***	-.0446***
	(.0073)	(.0171)	(.0172)
$ln(Office^{I}_{t-1})$	.0264**	.0163	.5236***
	(.0132)	(.0132)	(.1311)
$ln(Deposit^{I}_{t-1})$	.9639***	.8567***	.8529***
	(.2612)	(.2480)	(.2483)
DW_t	-.0066**	-.0133***	-.0124**
	(.0033)	(.0038)	(.0048)
DW_{t-1}	-.0058**	-.0143***	-.0201***
	(.0025)	(.0045)	(.0049)
$Listed * DW_t$	-.0088	-.0113	.0001
	(.0111)	(.0118)	(.0164)
$Listed * DW_t$	-.0050	-.0117	-.0272*
	(.0089)	(.0117)	(.0164)
Bond I.	-.0407	.0036	-.0140
	(.0466)	(.0769)	(.0779)
$S\&P$	.0282**	-.0143	-.0237
	(.0120)	(.0327)	(.0328)
Vix	-.0514	.0288	.0190
	(.0319)	(.0355)	(.0345)
GDP	-.0026**	-.0040**	-.0021
	(.0013)	(.0016)	(.0018)
DFA	.0178***	.0292***	.0277***
	(.0047)	(.0086)	(.0102)
Constant	.0551***	.1320***	.0611**
	(.0133)	(.0284)	(.0276)
Bank FE	Yes	Yes	Yes
Observations	38047	35449	35449
No. of groups	2341	2301	2301
R^2	.1286	.0940	.0450
F-test	14.3061***	14.0732***	6.6182***

	Panel B		
	(1)	(2)	(3)
	$\Delta MktShare^{O}_{t;t+1}$	$\Delta MktShare^{O}_{t;t+2}$	$\Delta MktShare^{O}_{t;t+3}$
	b/se	b/se	b/se
$ln(MktShare^{O}_{t-1})$	-.0683***	-.1384***	-.0788***
	(.0071)	(.0144)	(.0136)
$ln(Office^{O}_{t-1})$	.0532	.0599	1.3521**
	(.0332)	(.0439)	(.6505)
$ln(Deposit^{O}_{t-1})$	.7758**	.7211**	.7429**
	(.3526)	(.3437)	(.3601)
DW_t	.0012	-.0136	.0654
	(.0134)	(.0250)	(.0553)
DW_{t-1}	-.0161	-.0257	.0520
	(.0217)	(.0357)	(.0568)
$Listed * DW_t$	-.0055	.1299	.1752
	(.0571)	(.0795)	(.1637)
$Listed * DW_{t-1}$	.0821	.0541	.0024
	(.1147)	(.0890)	(.0888)
Bond I.	1.4536**	2.5320**	1.1348
	(.6407)	(1.0525)	(1.2537)
$S\&P$	.0919	-1.3078	-.8480
	(.0769)	(1.2045)	(.9566)
Vix	-.0648	.0121	.0290
	(.0695)	(.1336)	(.1311)
GDP	-.0200	-.0401	-.0806
	(.0204)	(.0417)	(.0775)
DFA	.0628*	.1627	-.0270
	(.0376)	(.1065)	(.0996)
Constant	.4663***	1.0177***	.7437***
	(.0556)	(.1007)	(.1132)
Bank FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Observations	12616	11992	11992
No. of groups	591	586	586
R^2	.0449	.0820	.0230
F-test	87.2562***	67.0330***	18.2866***

Robust clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.9: Discount Window: market share analysis –PSM–

Market share: inside deposits

	Panel A: Bank specific controls					Panel B: Bank-specific and office-deposit controls				
	Treated	Control	ATT	s.e.	t-stat	Treated	Control	ATT	s.e.	t-stat
$MktShare^{I}_{t+1}$	1062	14208	-0.209	0.087	-2.389	1006	12736	-0.208	0.103	-2.023
$MktShare^{I}_{t+2}$	1068	14340	-0.251	0.102	-2.461	1006	12736	-0.252	0.121	-2.086
$MktShare^{I}_{t+3}$	1068	14340	-0.299	0.129	-2.31	1006	12736	-0.299	0.101	-2.963
$\Delta MktShare^{I}_{t;t+1}$	1068	14340	-0.017	0.004	-4.278	1006	12736	-0.014	0.005	-3.127
$\Delta MktShare^{I}_{t;t+2}$	1068	14340	-0.027	0.008	-3.234	1006	12736	-0.024	0.005	-4.81
$\Delta MktShare^{I}_{t;t+3}$	1068	14340	-0.024	0.007	-3.592	1006	12736	-0.022	0.010	-2.197

Market share: outside deposits

	Panel A: Bank specific controls					Panel B: Bank-specific and office-deposit controls				
	Treated	Control	ATT	s.e.	t-stat	Treated	Control	ATT	s.e.	t-stat
$MktShare^{O}_{t+1}$	1068	14340	0.051	0.010	4.889	384	4854	0.057	0.008	6.806
$MktShare^{O}_{t+2}$	1068	14340	0.051	0.010	5.108	384	4854	0.058	0.014	4.31
$MktShare^{O}_{t+3}$	1068	14340	0.052	0.010	5.436	384	4854	0.060	0.012	4.823
$\Delta MktShare^{O}_{t;t+1}$	1068	14340	0.000	0.000	1.067	384	4854	0.000	0.000	1.271
$\Delta MktShare^{O}_{t;t+2}$	1068	14340	0.001	0.001	1.054	384	4854	0.001	0.000	1.777
$\Delta MktShare^{O}_{t;t+3}$	1068	14340	0.001	0.001	2.031	384	4854	0.001	0.001	1.427

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.10: Term Auction Facility: short-term deposits

	(1) Demand dep. b/se	(2) ST dep. b/se	(3) Non interest dep. b/se	(4) Liquid dep. b/se	(5) ST Non guaranteed dep. b/se
Panel A					
Contemporaneous effect: 1 quarter					
Demand					
$ln(Deposits_{t-1})$	-.0831***	-.1556***	.0295	-.0338**	-.2522***
	(.0296)	(.0398)	(.0266)	(.0131)	(.0247)
TAF	-2.2223***	1.4971***	-.4675**	-.4662**	2.9845***
	(.3828)	(.4261)	(.1821)	(.2191)	(.3545)
interest rate	-2.0535**	-.0117	1.0721	-.0092	-.0012**
	(.9879)	(.0100)	(.6569)	(.0071)	(.0006)
Controls	Yes	Yes	Yes	Yes	Yes
Supply					
$ln(Deposits_{t-1})$	-.0027	-.0351***	.0040	.0267***	-.0423***
	(.0055)	(.0082)	(.0036)	(.0090)	(.0073)
TAF	.3395	1.6598***	-.0921	-.6283*	2.3271***
	(.4051)	(.5128)	(.2625)	(.3698)	(.4377)
interest rate	-.0001	.0128	.5447***	-.0064	.0003
	(.2786)	(.0083)	(.1609)	(.0056)	(.0004)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	971	971	971	971	971
R^2	.4115	.0175	.0747	.0140	.8570
log(likelihood)	-1.52e+04	1675.5863	2.97e+04	1.16e+04	-3.82e+03
Panel B					
Information disclosure: after December 2010					
Demand					
$ln(Deposits_{t-1})$	.0001	-.0872**	.0987***	.0468	-.1185***
	(.0512)	(.0393)	(.0353)	(.0503)	(.0297)
TAF banks	1.5843***	.5790**	.6833***	1.7961***	.7766***
	(.4133)	(.2847)	(.2196)	(.5286)	(.2399)
interest	-3.7453**	-.7253	-.9152	2.6385	.0647
	(1.8049)	(1.3284)	(.7603)	(1.6462)	(1.0875)
Controls	Yes	Yes	Yes	Yes	Yes
Supply					
$ln(Deposits_{t-1})$	-.0108	-.0187	-.0040	-.0054	-.0176**
	(.0093)	(.0124)	(.0051)	(.0181)	(.0085)
TAF banks	.1426*	.0732	.0454	-.0280	.1152*
	(.0859)	(.0830)	(.0451)	(.1061)	(.0596)
interest	2.0769***	-1.4830	.9694***	1.6287**	2.2770
	(.5404)	(2.9039)	(.2622)	(.6647)	(2.9888)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	235	235	235	235	235
R^2	.3648	.1571	.1660	.2070	.6754
log(likelihood)	-1.09e+04	-440.2466	1617.1239	-1.46e+04	-245.6900

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.11: Term Auction facility: time deposits

	(1) Avg deposits b/se	(2) Domestic dep. b/se	(3) Time dep. NG b/se	(4) Time dep. G b/se	(5) Saving dep. b/se
			Panel A Contemporaneous effect: 1 quarter		
Demand					
$ln(Deposit_{t-1})$	-.0492***	-.0284*	-.2080***	-.0744***	-.0149
	(.0149)	(.0155)	(.0257)	(.0160)	(.0144)
TAF	.2824***	.1981***	1.7830***	.6628***	.5591***
	(.0546)	(.0518)	(.2223)	(.1854)	(.1003)
interest rate	.0001	.0001***	-.0003**	.0073***	-.4925*
	(.0030)	(.0000)	(.0001)	(.0024)	(.2624)
Supply					
$ln(Deposit_{t-1})$	.0013	.0020	-.0370***	-.0257***	.0059**
	(.0025)	(.0023)	(.0059)	(.0082)	(.0023)
TAF	.5830***	.4584***	2.0454***	2.3269***	-.0040
	(.1381)	(.1261)	(.3487)	(.4449)	(.1924)
interest rate	.0001*	.0001***	.0002*	-.0025	-.8746***
	(.0000)	(.0000)	(.0001)	(.0025)	(.1645)
Observations	978	978	978	978	978
R^2	.0089	.0567	.7250	.0823	.0900
log(likelihood)	5.11e+04	5.48e+04	5803.9075	4807.0122	3.08e+04
			Panel B Information disclosure: after December 2010		
Demand					
$ln(Deposit_{t-1})$	-.1055	-.0682	-.1168***	-.0633***	.0037
	(.0721)	(.0868)	(.0279)	(.0145)	(.0559)
TAF banks	.3504***	.4801***	.4973***	.1529	.3626*
	(.1193)	(.1320)	(.1810)	(.1357)	(.1877)
interest rate	-1.9988	.6655	-2.5482	-2.9554**	1.4640
	(1.4457)	(1.8521)	(2.1047)	(1.3057)	(1.5193)
Controls	Yes	Yes	Yes	Yes	Yes
Supply					
$ln(Deposit_{t-1})$	.0034	.0059**	-.0208***	-.0249***	-.0066
	(.0029)	(.0027)	(.0067)	(.0082)	(.0042)
TAF banks	-.0290	-.0290	.0899**	.1061**	.0397
	(.0213)	(.0197)	(.0459)	(.0525)	(.0345)
interest rate	-.5369	-.4861	.4224	-.4622	.5227
	(.3439)	(.3270)	(.7999)	(.6293)	(.5239)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	743	743	743	743	743
R^2	.0421	.3258	.6165	.0578	.4136
log(likelihood)	1.46e+04	1.27e+04	6378.4552	1.98e+04	1.14e+04

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.12: Term Auction Facility: cost of deposits

	(1) Interest on Domestic dep. b/se	(2) Quarterly avg cost of dep. b/se	(3) Interest on NG dep. b/se	(4) Interest on G dep. b/se
		Panel A Contemporaneous effect: 1 quarter		
Demand				
$ln(Interest_{j,t-1})$	-1.2924***	.0073***	-1.2184***	-.9807***
	(.0465)	(.0021)	(.0980)	(.1029)
$ln(Deposits_{j,t-1})$	-.0006**	.0338***	.0031**	.0025
	(.0003)	(.0100)	(.0014)	(.0016)
TAF	.0018***	.0094**	.0144***	.0070**
	(.0003)	(.0037)	(.0030)	(.0030)
Supply				
$ln(Interest_{t-1})$	-1.4156***	-.0001	-1.3198***	-.9650***
	(.0574)	(.0003)	(.1152)	(.1077)
$ln(Deposits_{t-1})$	.0002**	.0004	-.0024***	-.0002
	(.0001)	(.0008)	(.0008)	(.0008)
TAF	.0011***	-.0008	.0073**	.0053
	(.0004)	(.0035)	(.0036)	(.0035)
Observations	980	981	978	981
R^2	.6743	.7875	.4408	.3671
log(likelihood)	1.15e+04	5920.1202	6865.0834	7828.0356
		Panel B Information disclosure: after December 2010		
Demand				
$ln(Interest_{t-1})$	-.3730*	.1304	-.0470	-.0601
	(.2011)	(.1292)	(.1422)	(.1167)
$ln(Deposits_{t-1})$	-.0024**	.0004	-.0018*	.0002
	(.0011)	(.0050)	(.0011)	(.0021)
TAF banks	.0036***	.0087***	.0142***	.0144**
	(.0009)	(.0032)	(.0049)	(.0057)
Supply				
$ln(Interest_{t-1})$	-.7902***	-.3161***	-.7909***	-.3728***
	(.1210)	(.0769)	(.1578)	(.1293)
$ln(Deposits_{t-1})$	.0001*	.0011**	-.0004	.0014
	(.0001)	(.0005)	(.0008)	(.0010)
TAF banks	.0002	.0045*	.0048*	.0061
	(.0004)	(.0024)	(.0029)	(.0040)
Observations	743	744	744	744
R^2	.8919	.1449	.3203	.1427
log(likelihood)	7879.3906	5841.6675	5302.4434	5172.6537

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.13: Term Auction Facility: market share analysis –FE–

	(1) $\Delta MktShare^I_{t;t+1}$ b/se	(2) $\Delta MktShare^I_{t;t+2}$ b/se	(3) $\Delta MktShare^I_{t;t+3}$ b/se
		Panel A	
$Office^I_{t-1}$	.0178	-.0016	.5175***
	(.0136)	(.0149)	(.1292)
$Deposit^I_{t-1}$	.9876***	.9034***	.8744***
	(.2660)	(.2576)	(.2523)
TAF_{t-1}	.0868*	.2062**	.2730***
	(.0498)	(.1016)	(.1019)
$BondI._t$	-.0413	.0005	-.0155
	(.0468)	(.0776)	(.0798)
$S\&P_t$	.0271**	-.0233	-.0376
	(.0116)	(.0374)	(.0365)
VIX_t	-.0597*	.0184	.0112
	(.0330)	(.0379)	(.0358)
GDP_t	-.0023*	-.0031**	-.0014
	(.0012)	(.0014)	(.0016)
DFA	.0112**	.0162**	.0237**
	(.0045)	(.0081)	(.0105)
Constant	-.0105**	-.0054	-.0066
	(.0051)	(.0063)	(.0079)
Bank FE	Yes	Yes	Yes
Observations	38047	35449	35449
No. of groups	2341	2301	2301
F-test	7.3017***	9.9120***	6.1824***

		Panel B	
	(1) $\Delta MktShare^O_{t;t+1}$ b/se	(2) $\Delta MktShare^O_{t;t+2}$ b/se	(3) $\Delta MktShare^O_{t;t+3}$ b/se
$Office^O_{t-1}$	.0002	-.0000	.0132**
	(.0002)	(.0002)	(.0062)
$Deposit^O_{t-1}$	.0080**	.0077**	.0077**
	(.0036)	(.0036)	(.0036)
TAF_{t-1}	.0162	.0326	.0498
	(.0103)	(.0213)	(.0331)
$BondI._t$	.0160**	.0279***	.0148
	(.0074)	(.0102)	(.0111)
$S\&P_t$	-.0001	-.0149	-.0119
	(.0012)	(.0127)	(.0107)
VIX_t	-.0009	.0001	.0002
	(.0007)	(.0014)	(.0014)
GDP_t	-.0001	-.0002	-.0005
	(.0002)	(.0003)	(.0006)
DFA	-.0002	-.0003	-.0005
	(.0001)	(.0002)	(.0011)
Constant	-.0001	.0004	.0008***
	(.0003)	(.0003)	(.0003)
Bank FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Observations	12616	11992	11992
No. of groups	591	586	586
F-test	12.1392***	24.2921***	22.4683***

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.14: Term Auction Facility: market share inside

	(1)	(2)	(3)
Panel A			
	$\Delta MktShare^I_{t;t+1}$	$\Delta MktShare^I_{t;t+2}$	$\Delta MktShare^I_{t;t+3}$
	b/se	b/se	b/se
$ln(MktShare^I_{t-1})$	-.0466***	-.0939***	-.0430**
	(.0075)	(.0175)	(.0175)
$ln(Office^I_{t-1})$	.0263**	.0162	.5232***
	(.0132)	(.0132)	(.1303)
$ln(Deposit^I_{t-1})$	.9642***	.8566***	.8527***
	(.2609)	(.2472)	(.2472)
TAF_t	.0130	.0037	.0024
	(.0175)	(.0211)	(.0297)
TAF_{t-1}	-.0157	.0022	.0047
	(.0122)	(.0143)	(.0183)
$Listed * TAF_t$	-.0523	-.0331	-.0976
	(.0505)	(.0807)	(.1827)
$Listed * TAF_{t-1}$	.1351**	.2412***	.3966**
	(.0530)	(.0857)	(.1549)
Bond I.	-.0337	.0216	.0131
	(.0454)	(.0760)	(.0753)
$S\&P$	.0252**	-.0183	-.0317
	(.0122)	(.0316)	(.0310)
Vix	-.0521	.0250	.0140
	(.0321)	(.0361)	(.0356)
GDP	-.0025**	-.0035***	-.0014
	(.0012)	(.0013)	(.0016)
DFA	.0179***	.0300***	.0295**
	(.0052)	(.0097)	(.0117)
Constant	.0534***	.1269***	.0540*
	(.0143)	(.0304)	(.0298)
Bank FE	Yes	Yes	Yes
Observations	38047	35449	35449
No. of groups	2341	2301	2301
R^2	.1294	.0963	.0488
F-test	16.7174	19.6150	5.8574
Panel B			
	(1)	(2)	(3)
	$\Delta MktShare^O_{t;t+1}$	$\Delta MktShare^O_{t;t+2}$	$\Delta MktShare^O_{t;t+3}$
	b/se	b/se	b/se
$ln(MktShare^O_{t-1})$	-.0666***	-.1346***	-.0724***
	(.0084)	(.0171)	(.0194)
$ln(Office^O_{t-1})$	.0630*	.0763*	1.3708**
	(.0333)	(.0457)	(.6449)
$ln(Deposit^O_{t-1})$	.7783**	.7267**	.7519**
	(.3521)	(.3436)	(.3615)
TAF_t	-.0108	-.0271	-.0744
	(.0338)	(.0816)	(.0821)
TAF_{t-1}	.1010*	.2775*	.1647
	(.0520)	(.1667)	(.1286)
$Listed * TAF_t$	-.0297	.4783	1.4720
	(.6410)	(.7026)	(1.7006)
$Listed * TAF_{t-1}$	1.5181*	2.6392*	3.8766*
	(.8333)	(1.5370)	(2.3392)
Bond I.	1.6796**	3.0497***	1.9267**
	(.7674)	(1.1086)	(.9741)
$S\&P$	.0772	-1.2531	-.6673
	(.1140)	(1.1463)	(.7944)
Vix	-.0702	-.0080	-.0024
	(.0694)	(.1365)	(.1421)
GDP	-.0109	-.0197	-.0473
	(.0152)	(.0295)	(.0527)
DFA	.1178*	.2790*	.1646
	(.0612)	(.1615)	(.1503)
Constant	.3978***	.8663***	.4989**
	(.0949)	(.1688)	(.2093)
Bank FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Observations	12616	11992	11992
No. of groups	591	586	586
R^2	.0496	.0919	.0394
F-test	73.7787	49.9792	12.3376

Robust clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.15: Term Auction facility: market share –PSM–

	Panel A: Bank specific controls					Panel B: Bank-specific and office-deposit controls				
Market share: inside deposits										
	Treated	Control	ATT	s.e.	t-stat	Treated	Control	ATT	s.e.	t-stat
$MktShare_{t+1}$	289	19949	1.251	0.463	2.700	264	17516	0.635	0.575	1.104
$MktShare_{t+2}$	289	19949	1.342	0.323	4.157	264	17516	0.724	0.483	1.497
$MktShare_{t+3}$	289	19949	1.187	0.725	1.637	264	17516	0.627	0.57	1.121
$\Delta MktShare_{t+1}$	289	19949	0.010	0.007	1.259	264	17516	0.089	0.012	6.875
$\Delta MktShare_{t+2}$	289	19949	0.044	0.013	3.323	264	17516	0.064	0.008	7.493
$\Delta MktShare_{t+3}$	289	19949	0.043	0.015	2.772	264	17516	0.077	0.014	7.415
Info disclosure:	effect on June 2011									
$MktShare_{t+1}$	1153	9570	0.256	0.213	1.203	1078	8338	0.035	0.018	1.929
$\Delta MktShare_{t+1}$	1153	9570	0.02	0.003	6.752	1078	8338	0.017	0.003	4.331
Market share: outside deposits										
	Panel A: Bank specific controls					Panel B: Bank-specific and office-deposit controls				
	Treated	Control	ATT	s.e.	t-stat	Treated	Control	ATT	s.e.	t-stat
$MktShare_{t+1}$	289	19949	0.079	0.058	1.359	181	5454	0.098	0.046	2.133
$MktShare_{t+2}$	289	19949	0.093	0.077	1.2	181	5454	0.12	0.069	1.727
$MktShare_{t+3}$	289	19949	0.107	0.046	2.314	181	5454	0.135	0.043	3.115
$\Delta MktShare_{t+1}$	289	19949	0.013	0.012	1.053	181	5454	0.003	0.012	0.27
$\Delta MktShare_{t+2}$	289	19949	0.03	0.015	2.062	181	5454	0.019	0.019	1.038
$\Delta MktShare_{t+3}$	289	19949	0.039	0.022	1.748	181	5454	0.029	0.02	1.462
Info disclosure:	effect on June 2011									
$MktShare_{t+1}$	1153	9570	0.18	0.021	8.384	720	2878	0.124	0.033	3.763
$\Delta MktShare_{t+1}$	1153	9570	0.003	0.001	1.932	720	2878	0.003	0.001	2.575

Table 3.16: A comparison in 2010

	Panel A: effect on deposits		
	(1)	(2)	(3)
	Domestic dep.	Time dep. NG	Time dep. G
	b/se	b/se	b/se
Demand			
$ln(Deposit_{j,t-1})$	.1334***	-.0312	.1158**
	(.0343)	(.0659)	(.0460)
TAF	.3938*	.9961**	-.3695
	(.2237)	(.4510)	(.3749)
DW	.0841	-.0785	-.1087
	(.0732)	(.1353)	(.1270)
interest rate	.9356***	.2435	-.5322
	(.2778)	(.5362)	(.4317)
Controls	Yes	Yes	Yes
Supply			
$ln(Deposit_{j,t-1})$	-.0102***	-.0335***	-.0221***
	(.0034)	(.0060)	(.0060)
TAF	.0950***	.0898***	.0237
	(.0155)	(.0291)	(.0254)
DW	-.0925**	-.1123**	-.0808
	(.0410)	(.0576)	(.0676)
interest rate	.5395*	1.9011***	1.0418**
	(.2852)	(.7335)	(.5143)
Controls	Yes	Yes	Yes
Observations	3788	3777	3774
R^2	.2984	.2827	.3295
log(likelihood)	8393.6047	3406.6334	4273.4255

	Panel B: effect on cost of deposits			
	(1)	(2)	(3)	(4)
	Interest on Domestic dep.	Quarterly avg cost of dep.	Interest on NG dep.	Interest on G dep.
	b/se	b/se	b/se	b/se
Demand				
$Interest^j t-1$	4.5432***	-.0012	3.3629***	2.0923***
	(1.1099)	(.0036)	(.4107)	(.3128)
$log(Deposit_{j,t-1})$	.0103***	.0069	.0554***	.0340***
	(.0033)	(.0102)	(.0086)	(.0071)
DW	-.0406***	-.1640***	-.1517***	-.1832***
	(.0088)	(.0180)	(.0276)	(.0255)
TAF	.0559**	-.1469***	-.0253	-.0807
	(.0231)	(.0504)	(.0789)	(.0656)
Controls	Yes	Yes	Yes	Yes
Supply				
$Interest^j t-1$	-1.6674***	.0203***	-1.6097***	-1.6111***
	(.0425)	(.0023)	(.0312)	(.0264)
$log(Deposit_{j,t-1})$	-.0001*	-.0012*	-.0002	-.0001
	(.0000)	(.0007)	(.0003)	(.0003)
DW	.0034***	-.0042	.0215***	.0216***
	(.0008)	(.0105)	(.0042)	(.0039)
TAF	-.0005*	-.0391***	.0013	.0011
	(.0003)	(.0055)	(.0014)	(.0013)
Controls	Yes	Yes	Yes	Yes
Observations	3788	3789	3778	3775
R^2	.2740	.0468	.0820	.0473
log(likelihood)	3.09e+04	1.63e+04	1.88e+04	1.93e+04

Appendix A

Table A.1: Bank Holding Company: data definition and construction

Dataset	FRY-9C	Name
ln(TA)	BHCK3368	QUARTERLY AVERAGE OF TOTAL ASSETS
ln(Tafv)	BHCKG502	TOTAL ASSETS MEASURED AT FAIR VALUE ON A RECURRING BASIS
ASSETS_TAOBD_0RWA	BHCKB696	TOTAL ASSETS, DERIVATIVES, AND OFF-BALANCE SHEET ITEMS BY RISK WEIGHT CATEGORY - 0%
ASSETS_TAOBD_20RWA	BHCKB697	TOTAL ASSETS, DERIVATIVES, AND OFF-BALANCE SHEET ITEMS BY RISK WEIGHT CATEGORY - 20%
ASSETS_TAOBD_50RWA	BHCKB698	TOTAL ASSETS, DERIVATIVES, AND OFF-BALANCE SHEET ITEMS BY RISK WEIGHT CATEGORY - 50%
ASSETS_TAOBD_100RWA	BHCKB699	TOTAL ASSETS, DERIVATIVES, AND OFF-BALANCE SHEET ITEMS BY RISK WEIGHT CATEGORY - 100%
ln(repo)	BHCKB995	SECURITIES SOLD UNDER AGREEMENTS TO REPURCHASE
ln(FedRepo)	BHCK3353	QUARTERLY AVERAGE OF FEDERAL FUNDS PURCHASED AND SECURITIES SOLD UNDER AGREEMENTS TO REPURCHASE
ln(Com.Pap.)	BHCK2309	COMMERCIAL PAPER
ln(Interbank)	BHCK3190 + BHCK6555 + BHCK5043	
Other banks	BHCK3190	OTHER BORROWED MONEY
Sub. Vs Unrelated	BHCK6555	DEBT MATURING IN ONE YEAR OR LESS THAT IS ISSUED TO UNRELATED THIRD PARTIES BY BANK SUBSIDIARIES
Sub. Banks	BHCK5043	BALANCES DUE TO SUBSIDIARY BANKS OF THE BANK HOLDING COMPANY, GROSS
CAPITAL_QE	BHCK3519	QUARTERLY AVERAGE OF EQUITY CAPITAL
RISK_kCPPps	BHCKG234	ISSUANCES ASSOCIATED WITH THE U.S. DEPARTMENT OF TREASURY CAPITAL PURCHASE PROGRAM: SENIOR PERPETUAL PREFERRED STOCK OR SIMILAR ITEMS
RISK_kCPPcs	BHCKG235	ISSUANCES ASSOCIATED WITH THE U.S. DEPARTMENT OF TREASURY CAPITAL PURCHASE PROGRAM: WARRANTS TO PURCHASE COMMON STOCK OR SIMILAR ITEMS

Table A.2: Number of banks by state

State	**Code**	**N. of BHCs**	**Perc.**
Alaska	AK	1	0.06%
Alabama	AL	25	1.53%
Arkansas	AR	23	1.41%
Arizona	AZ	4	0.24%
California	CA	97	5.93%
Colorado	CO	21	1.28%
Connecticut	CT	22	1.35%
District of Columbia	DC	1	0.06%
Delaware	DE	8	0.49%
Florida	FL	80	4.89%
Georgia	GA	69	4.22%
Hawaii	HI	6	0.37%
Iowa	IA	37	2.26%
Idaho	ID	5	0.31%
Illinois	IL	111	6.79%
Indiana	IN	41	2.51%
Kansas	KS	36	2.20%
Kentucky	KY	28	1.71%
Louisiana	LA	29	1.77%
Massachusetts	MA	60	3.67%
Maryland	MD	18	1.10%
Maine	ME	14	0.86%
Michigan	MI	36	2.20%
Minnesota	MN	32	1.96%
Missouri	MO	51	3.12%
Mississippi	MS	23	1.41%
Montana	MT	7	0.43%
North Carolina	NC	45	2.75%
North Dakota	ND	11	0.67%
Nebraska	NE	16	0.98%
New Hampshire	NH	6	0.37%
New Jersey	NJ	47	2.87%
New Mexico	NM	8	0.49%
Nevada	NV	8	0.49%
New York	NY	73	4.46%
Ohio	OH	41	2.51%
Oklahoma	OK	27	1.65%
Oregon	OR	9	0.55%
Pennsylvania	PA	86	5.26%
Rhode Island	RI	4	0.24%
South Carolina	SC	24	1.47%
South Dakota	SD	15	0.92%
Tennessee	TN	45	2.75%
Texas	TX	117	7.16%
Utah	UT	8	0.49%
Virginia	VA	44	2.69%
Vermont	VT	6	0.37%
Washington	WA	35	2.14%
Wisconsin	WI	48	2.94%
West Virginia	WV	9	0.55%
Wyoming	WY	6	0.37%
	Others	12	0.73%
Total		1635	100.00%

This table reports the distribution of banks by US states (exception of District of Columbia which is in the list). Banks located in insular area and Commonwealth are within the category "Others".

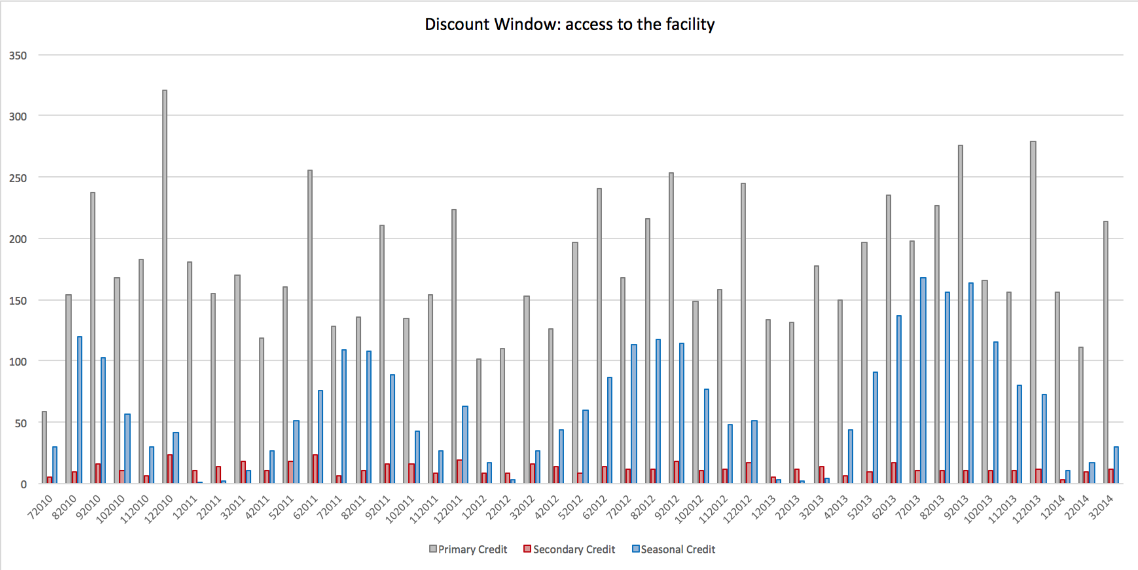


Figure A.1: Discount Window

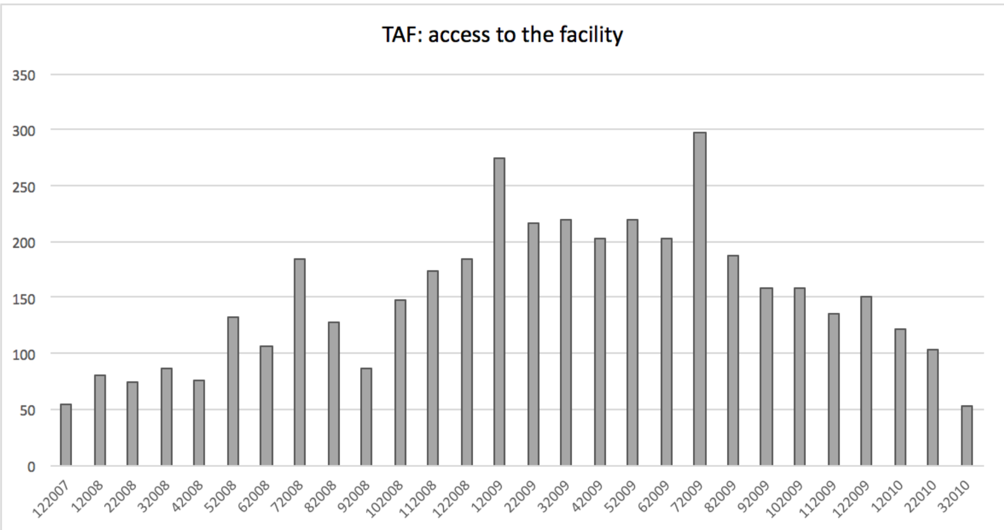


Figure A.2: Term Auction Facility

Table A.3: Fed districts

Fed district	**District code**	**N. Of BHCs**	**Percentage**
Boston	1	103	6.300%
New York	2	127	7.768%
Philadelphia	3	90	5.505%
Cleveland	4	70	4.281%
Richmond	5	140	8.563%
Atlanta	6	244	14.924%
Chicago	7	241	14.740%
St. Louis	8	122	7.462%
Minneapolis	9	76	4.648%
Kansas City	10	123	7.523%
Dallas	11	125	7.645%
San Francisco	12	174	10.642%
Total		1635	

Table A.4: Distribution of the facilities

PRG_type	Freq.	Percent	Cum.
Primary Credit	2,411	71.19	71.19
Seasonal Credit	259	7.72	79.63
Secondary Credit	257	7.66	87.27
TAF	427	12.73	100.00
Total	3,354	100.00	

This table reports the distribution of Discount Window and Term Auction Facility.

Table A.5: G-SIBs and D-SIBs

Type of SIFI	**Name**	**Stress test**	**SIFI**	**Capital Req.**
DSIB	Ally Financial	2009		
DSIB	American Express	2009		
GSIB	Bank of America	2009	2011	12.0% (CET1=min.8.5%)
GSIB	Bank of New York Mellon	2009	2011	11.5% (CET1=min.8%)
DSIB	BB&T	2009		
DSIB	BBVA Compass	2014		
DSIB	BMO Financial Corp.	2014		
DSIB	Capital One Financial	2009		
GSIB	Citigroup	2009	2011	12.5% (CET1=min.9%)
DSIB	Comerica	2014		
DSIB	Discover Financial Services	2014		
DSIB	Fifth Third Bank	2009		
GSIB	Goldman Sachs	2009	2011	12.0% (CET1=min.8.5%)
DSIB	HSBC North America Holdings	2014		
DSIB	Huntington Bancshares	2014		
GSIB	JP Morgan Chase	2009	2011	13.0% (CET1=min.9.5%)
DSIB	KeyCorp	2009		
DSIB	M&T Bank	2014		
DSIB	MetLife	2009 to 2012		-
GSIB	Morgan Stanley	2009	2011	12.0% (CET1=min.8.5%)
DSIB	Northern Trust	2014		
DSIB	PNC Financial Services	2009		
DSIB	RBS Citizens Financial Group	2014		
DSIB	Regions Financial	2009		
DSIB	Santander Holdings USA	2014		
GSIB	State Street	2009	2011	11.5% (CET1=min.8%)
DSIB	SunTrust Banks	2009		
DSIB	U.S. Bancorp	2009		
DSIB	UnionBanCal	2014		
GSIB	Wells Fargo	2009	2011	11.5% (CET1=min.8%)
DSIB	Zions	2014		

This table reports the list of banks designated as Domestically-SIBs or Globally-SIBs. The column "Stress Test" indicates the year starting from which they are subject to stress test, whilst the column "SIFI" indicates the year in which banks have been designated as G-SIBs and the last column indicates their specific capital requirements.

Appendix B

1913

Fed and Discount Window

- subsidised rate (r < target rate)
- banks had to prove exhausted liquidity

2003

Jan

Primary Credit

* rate: FOMC + 100bps.
* sound banks
* no-asked question program

Jan

Secondary Credit

* rate: FOMC + 150bps.
* no asset expansion
* funding liquidity needs

2007

Aug

DW revised

* rate: FOMC + 50bps. (Primary Credit)
* from overnight to 30 dd.

Dec

Term Auction Facility

2008

Mar

DW and TAF revised

* DW rate: FOMC + 25bps. (Primary Credit)
* TAF rate: minimum bid rate decreases
* TAF: amount offered from the Federal Reserve increased

Aug

Deposit insurance from 100 th to 250 th $

2010

Mar

Last TAF auction

Dec

TAF information disclosure on borrowers' names

2011

Mar

DW information disclosure on borrowers' names

* quarterly with two years lag

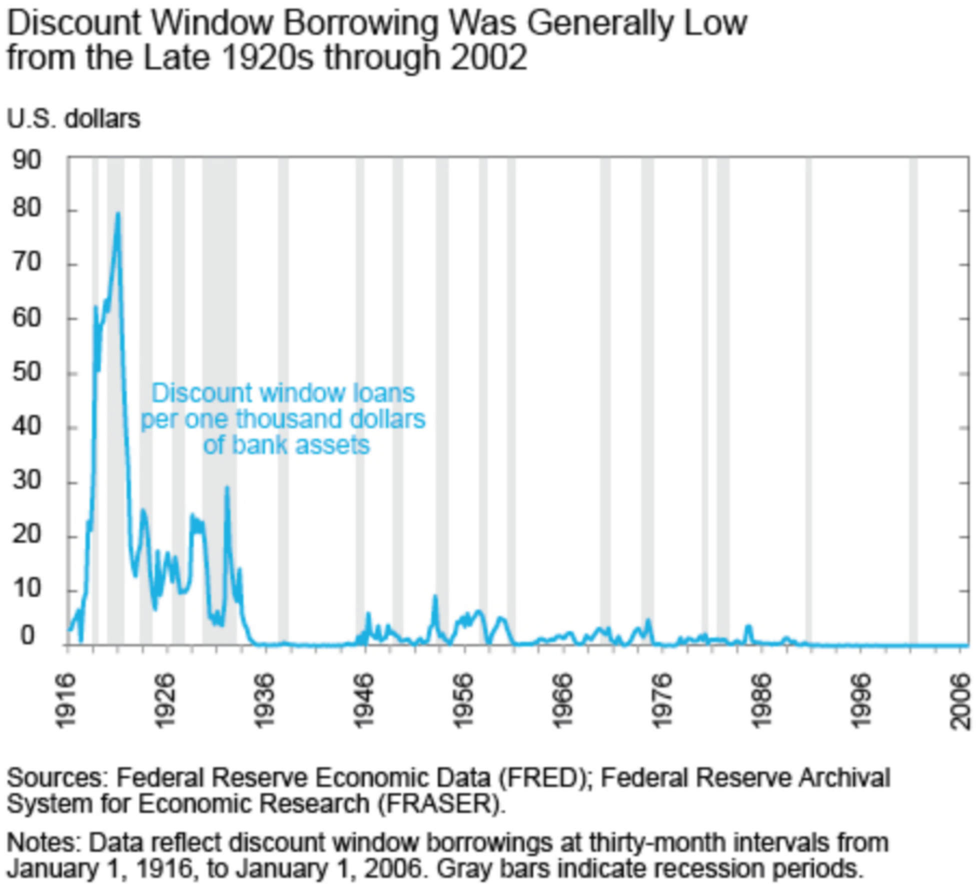


Figure B.1: Discount Window: historical borrowings

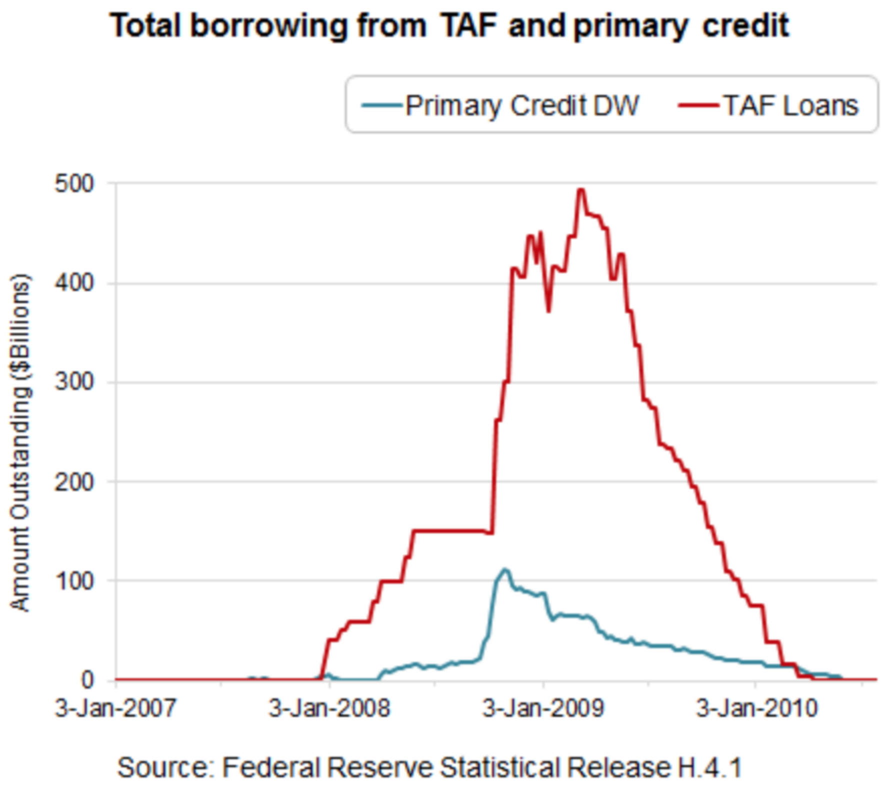


Figure B.2: Term Auction Facility: historical borrowings

Table B.1: Dynamic panel: Discount Window

Panel A: Short term deposits	(1)	(2)	(3)	(4)	(5)
	Demand dep.	ST dep.	Non interest dep.	Liquid dep.	ST Non guaranteed dep.
	b/se	b/se	b/se	b/se	b/se
$ln(Deposits_{j,t-1})$	.4058***	.2275***	.4025***	.3202***	.3475***
	(.0281)	(.0382)	(.0164)	(.0232)	(.0425)
$ln(Deposits_{j,t-2})$	.1785***	.0597*	.1729***	.0778***	.1393***
	(.0142)	(.0341)	(.0308)	(.0131)	(.0327)
$DW_{i,t-1}$	-.0052	-.1635	-.0182	-.5443**	-.2399**
	(.1439)	(.1141)	(.0901)	(.2749)	(.1119)
$DW_{i,t-2}$	.0151	-.0148**	.0017	-.0307*	-.0245**
	(.0113)	(.0071)	(.0060)	(.0176)	(.0120)
interest	-2.2709***	2.1621***	-1.6421***	-2.7701***	1.0176**
	(.6716)	(.5227)	(.4384)	(.7929)	(.4362)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	20675	20313	20744	20298	20383
No. of observations	1382	1366	1383	1364	1377
Wald	660.29***	114.48***	853.51***	350.67***	352.74***

Panel B: Long term deposits	(1)	(2)	(3)	(4)	(5)
	Avg deposits	Domestic dep.	Time dep. NG	Time dep. G	Saving dep.
	b/se	b/se	b/se	b/se	b/se
$ln(Deposits_{j,t-1})$	.5060***	.4800***	.7372***	.7568***	.7317***
	(.1280)	(.0729)	(.0869)	(.1208)	(.0372)
$ln(Deposits_{j,t-2})$	.1133	.0994***	.0382	.1488	.0537***
	(.0799)	(.0206)	(.0413)	(.1072)	(.0185)
$DW_{i,t-1}$	-.0116***	-.0112***	-.0102**	-.0125***	-.0134***
	(.0031)	(.0031)	(.0050)	(.0038)	(.0046)
$DW_{i,t-2}$	-.0075*	-.0042	-.0160***	.0001	.0001
	(.0045)	(.0026)	(.0053)	(.0057)	(.0037)
interest rate	-.5268**	-.5751**	.6417**	.3170	-.2251
	(.2113)	(.2444)	(.3249)	(.3148)	(.1771)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	20752	20753	20636	20640	20685
No. of observations	1384	1384	1377	1375	1379
Wald	104.77***	139.32***	453.40 ***	3019.69***	1170.25***

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.2: Dynamic panel cost of deposits: Discount Window

	(1) Interest on Domestic dep. b/se	(2) Quarterly avg cost of dep. b/se	(3) Interest on NG dep. b/se	(4) Interest on G dep. b/se
$ln(Interest_{j,t-1})$	-1.0028***	-.9989***	-.8535***	-.9233***
	(.0096)	(.0077)	(.0410)	(.0251)
$ln(Deposits_{j,t-1})$	.0006	-.0027	-.0004	-.0014
	(.0029)	(.0017)	(.0031)	(.0023)
$DW_{i,t}$	.0005	-.0079**	-.0082	-.0170**
	(.0007)	(.0036)	(.0076)	(.0071)
$DW_{i,t-1}$	-.0001**	-.0006***	-.0007**	-.0004
	(.0000)	(.0002)	(.0003)	(.0003)
ffr	-.0150***	-.0732***	-.0892***	-.0987***
	(.0004)	(.0021)	(.0048)	(.0047)
CP rate	.0042***	.0084***	.0193***	.0189***
	(.0004)	(.0022)	(.0060)	(.0049)
GDP	.0001***	.0007***	.0010***	.0010***
	(.0000)	(.0000)	(.0001)	(.0001)
$S\&P$	.0070***	.0402***	.0533***	.0509***
	(.0003)	(.0009)	(.0022)	(.0015)
Bond I.	.0159***	.0859***	.1043***	.1116***
	(.0003)	(.0017)	(.0033)	(.0028)
Cpi	-.1066***	-.6074***	-.7078***	-.7550***
	(.0022)	(.0115)	(.0173)	(.0150)
Vix	-.0012***	-.0074***	-.0114***	-.0106***
	(.0002)	(.0003)	(.0006)	(.0004)
Inv. bank	-.0002**	-.0008***	-.0015***	-.0015***
	(.0001)	(.0003)	(.0005)	(.0003)
Observations	18842	18844	18754	18745
No. of observations	1377	1378	1373	1370
F-test	4582.55***	11305.44***	948.51***	948.51***

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.3: Dynamic panel: Term Auction Facility

	Panel A: Short term deposits				
	(1)	(2)	(3)	(4)	(5)
	Demand dep.	ST dep.	Non interest dep.	Liquid dep.	ST Non guaranteed dep.
	b/se	b/se	b/se	b/se	b/se
$ln(Deposits_{j,t-1})$	.4508***	.3529***	.6476***	.3889***	.3646***
	(.0611)	(.0664)	(.0364)	(.0577)	(.0771)
$ln(Deposits_{j,t-2})$	.1217***	.0125	.0849**	.0932***	.0983***
	(.0226)	(.0323)	(.0375)	(.0168)	(.0341)
$TAF_{i,t-1}$	-.0334	.0427**	-.0373**	.0043	.1083***
	(.0342)	(.0192)	(.0167)	(.0362)	(.0275)
$TAF_{i,t-2}$	.0269	.0688**	.0595**	.0457	.0294
	(.0218)	(.0293)	(.0276)	(.0360)	(.0212)
interest	-.3520	-.0437	-.5161*	-.4031	-.5921*
	(.2714)	(.2557)	(.2927)	(.3167)	(.3241)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	15209	14760	15243	14966	15077
No. of observations	1203	1185	1207	1192	1197
Wald	71.82***	200.76***	303.12***	75.00***	218.93***
	Panel B: Long term deposits				
	(1)	(2)	(3)	(4)	(5)
	Avg deposits	Domestic dep.	Time dep. NG	Time dep. G	Saving dep.
	b/se	b/se	b/se	b/se	b/se
$ln(Deposits_{j,t-1})$	.5438***	.6089***	.5279***	.7032***	.6762***
	(.1518)	(.1055)	(.0880)	(.0914)	(.0519)
$ln(Deposits_{j,t-2})$	.1993**	.1310**	.0448*	.0286	.0905***
	(.0838)	(.0520)	(.0238)	(.0730)	(.0225)
$TAF_{i,t-1}$	-.0124	.0162	.0703***	.0378	.0148
	(.0123)	(.0151)	(.0167)	(.0231)	(.0193)
$TAF_{i,t-2}$	.0385*	.0263***	.0335*	.0289	.0058
	(.0197)	(.0073)	(.0171)	(.0196)	(.0115)
interest	-.9948***	-1.1710***	-1.0186***	-.4864*	-1.0786***
	(.2629)	(.2842)	(.3285)	(.2869)	(.2734)
Observations	15237	15237	15144	15134	15170
No. of observations	1206	1205	1197	1199	1199
F-test	47170.84***	59941.41***	1.35e+06***	1152.08***	1265.48***

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.4: Dynamic panel cost of deposits: Term Auction Facility

	(1) Interest on Domestic dep. b/se	(2) Quarterly avg cost of dep. b/se	(3) Interest on NG dep. b/se	(4) Interest on G dep. b/se
$ln(Interest_{j,t-1})$	-.9503***	-1.0820***	-.9856***	-1.0278***
	(.0110)	(.0048)	(.0171)	(.0294)
$ln(Deposits_{j,t-1})$	.0003	-.0036	-.0029	-.0070*
	(.0011)	(.0028)	(.0047)	(.0037)
$TAF_{i,t}$	.0175***	.0352***	.0601***	.0332
	(.0040)	(.0118)	(.0223)	(.0247)
$TAF_{i,t-1}$	.0004**	.0025***	.0028**	.0025**
	(.0002)	(.0005)	(.0012)	(.0011)
ffr	-.0074***	-.0375***	-.0395***	-.0386***
	(.0001)	(.0005)	(.0008)	(.0007)
CP rate	.0046***	.0164***	.0186***	.0133***
	(.0002)	(.0005)	(.0010)	(.0015)
GDP	.0001**	.0002***	.0006***	.0005***
	(.0000)	(.0001)	(.0001)	(.0001)
$S\&P$	.0133***	.0443***	.0479***	.0485***
	(.0004)	(.0011)	(.0022)	(.0037)
Bond I.	.0001	-.0143***	-.0304***	-.0282***
	(.0005)	(.0016)	(.0035)	(.0037)
Cpi	-.0674***	-.1696***	-.1335***	-.1616***
	(.0027)	(.0078)	(.0167)	(.0253)
Vix	-.0279***	-.1306***	-.1505***	-.1555***
	(.0004)	(.0012)	(.0023)	(.0021)
Inv. bank	-.0003**	.0009**	.0012*	.0003
	(.0001)	(.0004)	(.0007)	(.0006)
Observations	15238	15241	15153	15144
No. of observations	1194	1195	1187	1189
Wald	4550.56***	23209.02***	4499.72***	2688.37***

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Bibliography

Abbassi, P., Braeuning, F., Fecht, F., and Peydro, J.-L. (2014). Cross-border liquidity, relationships, and monetary policy: evidence from the Euro-area interbank crisis. *mimeo. Deutsche Bundesbank*.

Acharya, V., Engle, R., and Richardson, M. (2012). Capital shortfall: A new approach to ranking and regulating systemic risks. *The American Economic Review*, 102(3):59–64.

Acharya, V. V., Pedersen, L. H., Philippon, T., and Richardson, M. P. (2010). Measuring systemic risk.

Acharya, V. V. and Ryan, S. G. (2016). Banks' financial reporting and financial system stability. *Journal of Accounting Research*, 54(2):277–340.

Acharya, V. V. and Skeie, D. (2011). A model of liquidity hoarding and term premia in inter-bank markets. *Journal of Monetary Economics*, 58(5):436–447.

Acharya, V. V. and Steffen, S. (2015). The greatest carry trade ever? Understanding eurozone bank risks. *Journal of Financial Economics*, 115(2):215–236.

Acharya, V. V. and Tuckman, B. (2014). Unintended consequences of LOLR facilities: the case of illiquid leverage. *IMF Economic Review*, 62(4):606–655.

Adrian, T. and Brunnermeier, M. K. (2011). Covar. *American Economic Review*, 106(7):1705–1741.

Adrian, T., Colla, P., and Shin, H. S. (2012). Which financial frictions? Parsing the evidence from the financial crisis of 2007 to 2009. In *NBER Macroeconomics Annual 2012, Volume 27*, pages 159–214. University of Chicago Press.

Adrian, T., Moench, E., and Shin, H. S. (2013). Leverage asset pricing. *FRB of New York Staff Report*, (625).

Adrian, T. and Shin, H. S. (2010a). Financial intermediaries and monetary economics. *FRB of New York Staff Report*, (398).

Adrian, T. and Shin, H. S. (2010b). Liquidity and leverage. *Journal of Financial Intermediation*, 19(3):418–437.

Afonso, G., Kovner, A., and Schoar, A. (2011). Stressed, not frozen: The federal funds market in the financial crisis. *The Journal of Finance*, 66(4):1109–1139.

Allen, F., Babus, A., and Carletti, E. (2010). Financial connections and systemic risk. *National Bureau of Economic Research*, (w16177).

Allen, F. and Carletti, E. (2012). *Systemic risk and macroprudential regulation.* Palgrave Macmillan UK.

Allen, F. and Gale, D. (2000a). Bubbles and crises. *The Economic Journal*, 110(460):236–255.

Allen, F. and Gale, D. (2000b). Financial contagion. *Journal of Political Economy*, 108(1):1–33.

Allen, K. D., Hein, S. E., and Whitledge, M. D. (2015). The evolution of the Federal Reserve's Term Auction Facility and community bank utilization.

Allen, L., Bali, T. G., and Tang, Y. (2012). Does systemic risk in the financial sector predict future economic downturns? *Review of Financial Studies*, 25(10):3000–3036.

Amel-Zadeh, A., Barth, M. E., and Landsman, W. R. (2015). The contribution of bank regulation and fair value accounting to procyclical leverage. *Rock Center for Corporate Governance at Stanford University Working Paper*, (147).

Andersen, H. (2011). Pro-cyclical implications of Basel II: can the cyclicality of capital requirements be contained? *Journal of Financial Stability*, 7(3):138 – 154.

Armantier, O. and Copeland, A. M. (2012). Assessing the quality of "Furfine-Based" Algorithms.

Armantier, O., Ghysels, E., Sarkar, A., and Shrader, J. (2015). Discount Window stigma during the 2007–2008 financial crisis. *Journal of Financial Economics*, 118(2):317–335.

Armantier, O., Krieger, S., and McAndrews, J. (2008). The Federal Reserve's Term Auction Facility.

Arnold, E. A., Größl, I., and Koziol, P. (2016). Market discipline across bank governance models: empirical evidence from German depositors. *The Quarterly Review of Economics and Finance*, 61:126–138.

Artuç, E. and Demiralp, S. (2010). Discount Window borrowing after 2003: The explicit reduction in implicit costs. *Journal of Banking & Finance*, 34(4):825–833.

Bagehot, W. (1873). *Lombard Street: A description of the money market.* Scribner, Armstrong & Company.

Baglioni, A., Beccalli, E., Boitani, A., and Monticini, A. (2013). Is the leverage of european banks procyclical? *Empirical Economics*, 45(3):1251–1266.

Balasubramnian, B. and Cyree, K. B. (2014). Has market discipline on banks improved after the Dodd–Frank Act? *Journal of Banking & Finance*, 41:155–166.

Bayazitova, D. and Shivdasani, A. (2012). Assessing TARP. *Review of Financial Studies*, 25(2):377–407.

BCBS and FSF (2009). The role of valuation and leverage in procyclicality. *Bank for International Settlements and Financial Stability Forum.*

Beccalli, E., Boitani, A., and Di Giuliantonio, S. (2015). Leverage pro-cyclicality and securitization in US banking. *Journal of Financial Intermediation*, 24(2):200–230.

Bech, M. L. and Klee, E. (2011). The mechanics of a graceful exit: Interest on reserves and segmentation in the federal funds market. *Journal of Monetary Economics*, 58(5):415–431.

Benmelech, E. (2012). An empirical analysis of the Fed's Term Auction Facility. Technical report, National Bureau of Economic Research.

Benmelech, E. and Bergman, N. K. (2009). Collateral pricing. *Journal of financial Economics*, 91(3):339–360.

Benston, G. J. (1993). Market discipline: the role of uninsured depositors and other market participants.

Berger, A. N., Black, L. K., Bouwman, C. H., and Dlugosz, J. (2015). The Federal Reserve's Discount Window and TAF programs: "pushing on a string?".

Berger, A. N., Bouwman, C. H., Kick, T., and Schaeck, K. (2016a). Bank liquidity creation following regulatory interventions and capital support. *Journal of Financial Intermediation*, 26:115–141.

Berger, A. N., Davies, S. M., and Flannery, M. J. (1998). Comparing market and supervisory assessments of bank performance: who knows what when?

Berger, A. N., Roman, R. A., and Sedunov, J. (2016b). Do bank bailouts reduce or increase systemic risk? The effects of TARP on financial system stability. *Federal Reserve Bank of Kansas City Research Working Paper.*

Berger, A. N. and Turk-Ariss, R. (2015). Do depositors discipline banks and did government actions during the recent crisis reduce this discipline? An international perspective. *Journal of Financial Services Research*, 48(2):103–126.

Berger, A. N. and Udell, G. F. (2004). The institutional memory hypothesis and the procyclicality of bank lending behavior. *Journal of financial intermediation*, 13(4):458–495.

Berry, J. (2012). Bloomberg vs. the Fed. *The International Economy*, 26(1):65.

Bertay, A. C., Demirgüç-Kunt, A., and Huizinga, H. (2015). Bank ownership and credit over the business cycle: Is lending by state banks less procyclical? *Journal of Banking & Finance*, 50:326–339.

Bikker, J. A. and Metzemakers, P. A. (2005). Bank provisioning behaviour and procyclicality. *Journal of international financial markets, institutions and money*, 15(2):141–157.

Billio, M., Getmansky, M., Lo, A. W., and Pelizzon, L. (2010). Measuring systemic risk in the finance and insurance sectors. *MIT Sloan School of Management Working Paper*, 10(4774).

Billio, M., Getmansky, M., Lo, A. W., and Pelizzon, L. (2012). Econometric measures of connectedness and systemic risk in the finance and insurance sectors. *Journal of Financial Economics*, 104(3):535–559.

Birchler, U. and Maechler, A. M. (2001). Do depositors discipline Swiss banks? Technical report, Working Paper, Study Center Gerzensee.

Black, L. K. and Hazelwood, L. N. (2013). The effect of TARP on bank risk-taking. *Journal of Financial Stability*, 9(4):790–803.

Blau, B. M., Hein, S. E., and Whitby, R. J. (2016). The financial impact of lender-of-last-resort borrowing from the Federal Reserve during the financial crisis. *Journal of Financial Research*, 39(2):179–206.

Bomberger, W. A. (1993). Income, wealth, and household demand for deposits. *The American Economic Review*, 83(4):1034–1044.

Bongini, P., Nieri, L., and Pelagatti, M. (2015). The importance of being Systemically Important Financial Institutions. *Journal of Banking & Finance*, 50:562–574.

Brave, S. A. and Genay, H. (2011). *Federal Reserve policies and financial market conditions during the crisis.* DIANE Publishing.

Brei, M. and Gambacorta, L. (2014). The leverage ratio over the cycle. *BIS Working Paper*, (471).

Brei, M. and Gambacorta, L. (2016). Are bank capital ratios pro-cyclical? New evidence and perspectives. *Economic Policy*, 31(86):357–403.

Broecker, T. (1990). Credit-worthiness tests and interbank competition. *Econometrica: Journal of the Econometric Society*, 58(2):429–452.

Brownlees, C. and Engle, R. F. (2016). Srisk: A conditional capital shortfall measure of systemic risk. *Review of Financial Studies*.

Brownlees, C. T. and Engle, R. F. (2012). Volatility, correlation and tails for systemic risk measurement. *Manuscript, Stern School of Business, New York University.*

Brunnermeier, M. K. (2009). Deciphering the liquidity and credit crunch 2007–2008. *The Journal of economic perspectives*, 23(1):77–100.

Calomiris, C. W. (1999). Building an incentive-compatible safety net. *Journal of Banking & Finance*, 23(10):1499–1519.

Calomiris, C. W. and Khan, U. (2015). An assessment of TARP assistance to financial institutions. *The Journal of Economic Perspectives*, 29(2):53–80.

Caruana, J. (2010). Systemic risk: how to deal with it. *Bank for International Settlements*.

Castro, C. and Ferrari, S. (2014). Measuring and testing for the Systemically Important Financial Institutions. *Journal of Empirical Finance*, 25:1–14.

Cecchetti, S. G. (2009). Crisis and responses: the Federal Reserve in the early stages of the financial crisis. *The Journal of Economic Perspectives*, 23(1):51–75.

Chesini, G. and Giaretta, E. (2015). Moving towards a pan-european deposit guarantee scheme: How bank riskiness is relevant in the scheme. In *Bank Risk, Governance and Regulation*, pages 66–104. Springer.

Clouse, J. A. (1994). Recent developments in Discount Window policy. *Fed. Res. Bull.*, 80:965.

Cook, D. O. and Spellman, L. J. (1994). Repudiation risk and restitution costs: toward understanding premiums on insured deposits. *Journal of Money, Credit and Banking*, 26(3):439–459.

Crotty, J. (2009). Structural causes of the global financial crisis: a critical assessment of the new financial architecture? *Cambridge Journal of Economics*, 33(4):563–580.

Cyree, K. B., Griffiths, M. D., and Winters, D. B. (2013). Federal Reserve financial crisis lending programs and bank stock returns. *Journal of Banking & Finance*, 37(10):3819–3829.

Damar, H. E., Meh, C. A., and Terajima, Y. (2013). Leverage, balance-sheet size and wholesale funding. *Journal of Financial Intermediation*, 22(4):639–662.

Darrat, A. F., Elkhal, K., Banerjee, G., and Zhong, M. (2004). Why do us banks borrow from the Fed? a fresh look at the "reluctance" phenomenon. *Applied Financial Economics*, 14(7):477–484.

Davidson, R., MacKinnon, J. G., et al. (1993). Estimation and inference in econometrics.

Dell'Ariccia, G. and Marquez, R. (2006). Lending booms and lending standards. *The Journal of Finance*, 61(5):2511–2546.

Demirgüç-Kunt, A. and Detragiache, E. (2002). Does deposit insurance increase banking system stability? An empirical investigation. *Journal of monetary economics*, 49(7):1373–1406.

Demsetz, R. and Strahan, P. (1997). Diversification, size, and risk at bank holding companies. *Journal of Money, Credit and Banking*, 29(3):300–313.

Detragiache, E. and Spilimbergo, A. (2004). Empirical models of short-term debt and crises: Do they test the creditor run hypothesis? *European Economic Review*, 48(2):379–389.

Diamond, D. W. and Dybvig, P. H. (1983). Bank runs, deposit insurance, and liquidity. *The Journal of Political Economy*, pages 401–419.

Diamond, D. W. and Rajan, R. (2009). The credit crisis: conjectures about causes and remedies. Technical report, National Bureau of Economic Research.

Diamond, D. W. and Rajan, R. G. (2005). Liquidity shortages and banking crises. *The Journal of Finance*, 60(2):615–647.

Dick, A. A. (2008). Demand estimation and consumer welfare in the banking industry. *Journal of Banking & Finance*, 32(8):1661–1676.

Diebold, F. X. and Yilmaz, K. (2013). Measuring the dynamics of global business cycle connectedness. *PIER Working Paper*.

Disli, M., Schoors, K., and Meir, J. (2013). Political connections and depositor discipline. *Journal of Financial Stability*, 9(4):804–819.

Egan, M., Hortaçsu, A., and Matvos, G. (2017). Deposit competition and financial fragility: evidence from the us banking sector. *The American Economic Review*, 107(1):169–216.

Ennis, H. M. and Weinberg, J. A. (2013). Over-the-counter loans, adverse selection, and stigma in the interbank market. *Review of Economic Dynamics*, 16(4):601–616.

Estrella, A. (2004). The cyclical behavior of optimal bank capital. *Journal of banking & finance*, 28(6):1469–1498.

Faia, E. and Ottaviano, G. (2015). Towards a theory of global bank risk taking and competition. Technical report, mimeo.

Flannery, M. J. (1998). Using market information in prudential bank supervision: a review of the us empirical evidence. *Journal of Money, Credit and Banking*, pages 273–305.

Fleming, M. J. (2012). Federal reserve liquidity provision during the financial crisis of 2007–2009. *Annu. Rev. Financ. Econ.*, 4(1):161–177.

Fostel, A. and Geanakoplos, J. (2008). Leverage cycles and the anxious economy. *The American Economic Review*, 98(4):1211–1244.

Freixas, X., Giannini, C., Hoggarth, G., and Soussa, F. (1999). Lender Of Last Resort: a review of the literature. *Financial stability review*, 7:151–167.

Freixas, X., Laeven, L., and Peydro, L. (2015). *Systemic risk, crises and macroprudential policy*. MIT Press.

Freixas, X., Parigi, B. M., and Rochet, J.-C. (2000). Systemic risk, interbank relations, and liquidity provision by the central bank. *Journal of Money, Credit and Banking*, pages 611–638.

Furfine, C. (2003). Standing facilities and interbank borrowing: evidence from the federal reserve's new discount window. *International Finance*, 6(3):329–347.

Gambacorta, L. and Mistrulli, P. E. (2004). Does bank capital affect lending behavior? *Journal of Financial intermediation*, 13(4):436–457.

Gilbert, R. A., Kliesen, K. L., Meyer, A. P., and Wheelock, D. C. (2012). Federal Reserve lending to troubled banks during the financial crisis, 2007-10.

Girotti, M. (2016). How monetary policy changes bank liability structure and funding cost.

Goday, V., Gruss, B., and Moreno, J. P. (2005). Depositors discipline in uruguayan banks. *Revista de economía*, 12(2):167–190.

Gorton, G. and Metrick, A. (2012). Securitized banking and the run on repo. *Journal of Financial Economics*, 104(3):425–451.

Greene, W. H. (2012). Econometric analysis, 71e. *Stern School of Business, New York University*.

Hannan, T. H. and Prager, R. A. (2004). The competitive implications of multimarket bank branching. *Journal of Banking & Finance*, 28(8):1889–1914.

Hart, O. and Zingales, L. (2011). A new capital regulation for large financial institutions. *American Law and Economics Review*, 13(2):453–490.

Hautsch, N., Schaumburg, J., and Schienle, M. (2014). Financial network systemic risk contributions. *Review of Finance*, 19(2):685–738.

Heitfield, E. and Prager, R. A. (2004). The geographic scope of retail deposit markets. *Journal of Financial Services Research*, 25(1):37–55.

Helwege, J., Boyson, N. M., and Jindra, J. (2017). Thawing frozen capital markets and backdoor bailouts: Evidence from the Fed's liquidity programs. *Journal of Banking & Finance*, 76:92–119.

Hoggarth, G., Jackson, P., and Nier, E. (2005). Banking crises and the design of safety nets. *Journal of Banking & Finance*, 29(1):143–159.

Huizinga, H. and Laeven, L. (2012). Bank valuation and accounting discretion during a financial crisis. *Journal of Financial Economics*, 106(3):614–634.

Imbens, G. W. and Wooldridge, J. M. (2009). Recent developments in the econometrics of program evaluation. *Journal of economic literature*, 47(1):5–86.

Ivashina, V. and Scharfstein, D. (2010). Bank lending during the financial crisis of 2008. *Journal of Financial economics*, 97(3):319–338.

Ivry, B., Keoun, B., Kuntz, P., et al. (2011). Secret Fed loans gave banks 13 billion undisclosed to Congress. *Bloomberg Markets Magazine*, 28.

Jean-Charles Rochet, J. T. (1996). Interbank lending and systemic risk. *Journal of Money, Credit and Banking*, 28(4):733–762.

Jordan, J. S. (2000). Depositor discipline at failing banks. *New England Economic Review*, page 15.

Karas, A., Pyle, W., and Schoors, K. (2010). How do russian depositors discipline their banks? Evidence of a backward bending deposit supply function. *Oxford Economic Papers*, 62(1):36–61.

Karas, A., Pyle, W., and Schoors, K. (2013). Deposit insurance, banking crises, and market discipline: Evidence from a natural experiment on deposit flows and rates. *Journal of Money, Credit and banking*, 45(1):179–200.

Kiyotaki, N. and Moore, J. (1995). Credit cycles. Technical report, National Bureau of Economic Research.

Kiyotaki, N. and Moore, J. (2002). Balance-sheet contagion. *The American Economic Review*, 92(2):46–50.

Kleymenova, A. (2016). Consequences of mandated bank liquidity disclosures.

Laeven, L., Ratnovski, L., and Tong, H. (2015). Bank size, capital, and systemic risk: Some international evidence. *Journal of Banking & Finance*, 69:25–34.

Laseen, S., Pescatori, A., and Turunen, M. J. (2015). *Systemic Risk: A New Trade-off for Monetary Policy?* Number 15-142. International Monetary Fund.

Levy-Yeyati, E., Martinez Peria, M. S., and Schmukler, S. L. (2010). Depositor behavior under macroeconomic risk: evidence from bank runs in emerging economies. *Journal of Money, Credit and Banking*, 42(4):585–614.

Macey, J. R. and Garrett, E. H. (1988). Market discipline by depositors: a summary of the theoretical and empirical arguments. *Yale J. on Reg.*, 5:215.

Maechler, A. M. and McDill, K. M. (2006). Dynamic depositor discipline in US banks. *Journal of Banking & Finance*, 30(7):1871–1898.

Martinez Peria, M. S. and Schmukler, S. L. (2001). Do depositors punish banks for bad behavior? Market discipline, deposit insurance, and banking crises. *The journal of finance*, 56(3):1029–1051.

Moenninghoff, S. C., Ongena, S., and Wieandt, A. (2015). The perennial challenge to counter Too-Big-to-Fail in banking: Empirical evidence from the new international regulation dealing with Global Systemically Important Banks. *Journal of Banking & Finance*, 61:221–236.

Morrison, A. D. and White, L. (2011). Deposit insurance and subsidized recapitalizations. *Journal of Banking & Finance*, 35(12):3400–3416.

Nier, E. and Baumann, U. (2006). Market discipline, disclosure and moral hazard in banking. *Journal of Financial Intermediation*, 15(3):332–361.

Park, S. (1995). Market discipline by depositors: evidence from reduced-form equations. *The Quarterly Review of Economics and Finance*, 35:497–514.

Park, S. and Peristiani, S. (1998). Market discipline by thrift depositors. *Journal of Money, Credit and Banking*, pages 347–364.

Repullo, R. and Suarez, J. (2013). The procyclical effects of bank capital regulation. *Review of Financial Studies*, 26(2):452–490.

Rochet, J.-C. and Vives, X. (2004). Coordination failures and the Lender Of Last Resort: was Bagehot right after all? *Journal of the European Economic Association*, 2(6):1116–1147.

Semenova, M. et al. (2007). How depositors discipline banks: the case of Russia. Technical report, EERC Research Network, Russia and CIS.

Shin, H. S. (2010). Procyclicality and systemic risk: What is the connection.

Tasca, P. and Battiston, S. (2016). Market procyclicality and systemic risk. *Quantitative Finance*, 16(8):1219–1235.

Taylor, J. B. and Williams, J. C. (2009). A black swan in the money market. *American Economic Journal: Macroeconomics*, 1(1):58–83.