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Essays on Bank Risk

Dottorando

Sclip Alex

Supervisore

Prof. Stefano Miani

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Abstract

This thesis comprises research on banks' risk. The work is presented in three empirical essays.

The first essay investigates the relationship between bank capital and liquidity and the impact of those connections on the market probability of default. Using quarterly balance sheet data of large European banks over the period 2005-2015 and various configurations of capital and liquidity; we first analyse through a simultaneous equation model the connections between capital and liquidity. The results of the model show a bidirectional positive relationship between capital and funding liquidity risk in line with the "financial fragility" and the "crowding out of deposits" hypotheses developed in theoretical papers. The results also indicate the importance of off-balance sheet exposures and the limitation of risk based capital ratios in explaining the relationship. Given the importance of capital and liquidity for financial stability, in the second part of the paper we explore whether those variables provide incremental information on banks' risk. To do so, we use a factor model to analyse if leverage and funding liquidity risk are reflected in CDS spreads. We find that capital appears to have a large impact on CDS spread changes, while liquidity risk is priced only when it falls below the regulatory threshold.

The second essay examines the causal effect of bank credit rating changes on bank capital structure decisions. In this paper, we hypothesize that bank managers' concern for credit ratings due to the discrete cost and benefits associated with different credit levels. Using a unique data set with quarterly detailed information on rating changes and bank's balance sheets for 76 banks based in EU and US from 2005Q1 to 2015Q4, we find that rating changes matter for bank capital structure decisions. More precisely, we find that a downgrade event triggers reductions in leverage, long-term funding and lending. While upgrades do not cause capital structure adjustments. In doing our empirical exercise, we also exploit the asymmetric impact of rating changes of banks based in countries that experienced the sovereign debt crisis. This asymmetric effect leads to greater: capital adjustments, reductions in long-term funding and lending of banks from those stressed countries.

The third essay examines how bank risks affects the transmission mechanism of unconventional monetary policy measures taken by the Federal Reserve (FED) in response to the financial crisis. Using quarterly balance sheet data and employing a GMM approach, for a sample of 149 US banks over the period 2007 to 2016, I find that bank risk positions are relevant for the transmission mechanism through the bank lending channel during the FED Quantitative easing (QE) programmes. The empirical findings suggest that QE programs helped banks to supply new loans through the reduction of bank risk conditions, as perceived by financial market investors.

The research works of my thesis contributes to the knowledge of banks' risk and provide several policy implications related to the recent discussions of how to redesign regulation of the banking sector.

The first paper provides three main policy implications. Firstly, our results cast doubts on the accuracy of Basel II capital formulations and support the efforts of the Basel Committee to revise the leverage requirements of the banking sector. Secondly, we highlight the importance of implementing minimum liquidity ratios concomitant with leverage ratios, as we shown that capital and liquidity are closely related to each other. Thirdly, we provide evidence that prices in the CDS market incorporates promptly information on leverage and funding liquidity risk. Therefore, supervisors might exercise indirect market discipline through the monitoring of such derivatives.

In the second paper, we demonstrate the importance of bank credit ratings for capital structure decisions. Our results demonstrate that credit ratings changes have economic and decision-making consequences for banks. Moreover, we also show that deteriorating sovereign credit quality has an impact even for healthy banks. Based on our results, we call for a rethinking on the role of credit rating agencies in the context of regulation and supervisory schemes.

Finally, the last paper provides some policy implications on the way monetary policy was conducted in the U.S.. In particular, the results suggest that the impact of unconventional monetary policy actions can be amplified or attenuated by changes in the investors' perception of risk of the banking sector. This result call for a further close coordination between monetary policy and supervisory activities within central banks, with the aim of increasing the efficiency and stability of the entire financial sector.

Large EU banks' capital and liquidity: Relationship and impact on CDS spreads

Claudia Girardone
Essex Business School
University of Essex
Colchester, CO4 3 SQ, UK
cgirard@essex.ac.uk

Stefano Miani
Department of Economics and Statistics
University of Udine
Via Tomadini 30A – 33100 Udine
stefano.miani@uniud.it

Alex Sclip[1]
Department of Economics and Statistics
University of Udine
Via Tomadini 30A – 33100 Udine
sclip.alex@spes.uniud.it

Abstract

This paper explores the interrelations between bank capital and liquidity and their impact on the market probability of default. We employ an unbalanced panel of large EU banks with listed CDS contracts during the period 2005-2015, which allow us to consider the impact of the recent financial crisis. Our evidence suggests that bank capital and funding liquidity risk as defined in Basel III have an economically meaningful bidirectional relationship. However, the effect on CDS spread is ambiguous. While capital has a large impact on CDS spread changes, liquidity risk is priced only when it falls below the regulatory threshold.

Keywords: Bank capital, liquidity, CDS spreads.

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1.Introduction

In normal times, asset markets are buoyant and funding is readily and cheaply available. The rapid changes in market conditions in the second half of the 2000s and the financial crisis that followed have shown that liquidity can dry up very quickly and that it can take a long time to come back. Many large banks in the US and Europe, experienced financial difficulties despite meeting the existing regulatory capital requirements because they did not prudently manage their liquidity. With greater liquidity and maturity transformation risk, central banks had to take action both in money markets and individual institutions. Eventually, the Basel Committee on Banking Supervision (BCBS) proposed two standards for liquidity risk and a revision of capital requirements[2] emphasising the importance of solvency requirements in conjunction with liquidity creation. In practice, however, the causal relationship between capital and liquidity discussed in theoretical papers (Diamond and Dybvig, 1983; Diamond and Rajan, 2000) and inferred in BCBS statements (BCBS, 2010a), is far from straightforward and might be jointly determined.

The traditional role of banks is to perform maturity transformation. This contributes to efficient resource allocation and credit creation. However, while banks holding riskier assets should strengthen their capital to face unexpected losses from selling some assets at fire-sale prices, banks relying on a higher proportion of unstable funding sources for their activities, may need to hold more liquid assets to deal with liquidity risk. The problem is that banks have weak private incentives to limit excessive reliance on unstable funding of core (often illiquid) assets. Banks may also have private incentives to increase leverage, and to expand their balance sheets relying on relatively cheap and abundant short-term wholesale funding. Rapid balance sheet growth can weaken the ability of individual banks to respond to liquidity, as well as solvency, shocks, and can have systemic implications when banks fail to internalise the costs associated with large funding gaps. A highly interconnected financial system tends to exacerbate these spillovers.

The financial crisis has demonstrated the instability that can result from banks having insufficient financial resources in terms of capital or liquidity. It has also highlighted the need to develop models and market indicators that could help identify the possible weaknesses of large banking institutions in terms of capital and liquidity that can trigger systemic risk to the entire financial system. Capital and liquidity may provide incremental information about the banks' credit risk (Chiaramonte and Casu, 2016; Vazquez and Federico, 2015) and CDS spreads seem ideal because they give a direct measure of banks' default risk. In particular, CDSs may be considered a timely indicator of credit risk arising from insufficient resources of capital and liquidity.

[2] For detailed information on the new regulatory requirements, refers to BCBS (2009; 2010a; 2010b).

This paper contributes to the extant literature in several ways. First, to best of our knowledge, it is the first study to provide an empirical investigation of the simultaneous interrelation between capital and liquidity in European banks and to extend the analysis to the impact of these variables on CDS spread changes. Published studies typically focus either on the interrelations between capital and liquidity (e.g., Distinguin et al., 2013) or on the determinants of CDS spread changes (Casu and Chiaramonte, 2011; Hasan et al., 2015).

Second, we employ a sample of large banks operating in the euro area over 2005-2015 thereby allowing us to consider the impact of both the global financial crisis and the euro sovereign debt crisis. We focus on large banks because they account for roughly 90% of aggregate bank liquidity, they typically have an easier access to the lender-of-last resort function and would be first to benefit from safety nets, as noted in Distinguin et al. (2013). As far as we are aware, no other published studies conducted an empirical investigation on the relationship between capital and liquidity in the context of the crisis. For example, Distinguin et al. (2013) analyses the period before the financial crisis: 2000-2006; Hovarth et al. (2012) uses a sample of Czech banks from 2000 to 2010. In addition, while existing studies employ yearly on-balance sheet data, in our paper we rely on quarterly data and we also consider large banks' off-balance sheet exposures which have previously been found as important determinants of liquidity risk management (Ippolito et al., 2016).

Third, we extend the literature in several directions. This paper analyses the relationship between capital and liquidity in a way consistent with the formulations of the most recent international regulatory framework for banks (Basel III). In particular, we use two different configurations of the Net Stable Funding Ratio (NSFR) as a measure of illiquidity and three classes of formulations of capital: the leverage ratio defined in Basel III, the risk-weight capital ratios defined in Basel II and a market-based measure of capital. Once we examine the complex interrelations between capital and liquidity, we add to the literature by providing in the second part of the analysis an empirical test to identify whether and to what extent market participants in the derivative (CDS) markets incorporate information on capital and liquidity into CDS spreads. It is expected that if investors exercised market discipline in the banking sector through the assessment of bank risk profiles into CDS spreads, supervisors should detect the weaknesses that can arise from banks having insufficient resources in terms of capital and liquidity indirectly, through the monitoring of the derivative market. We focus on the CDS market because participation is dominated by institutional investors that tend to be better informed and equipped to monitor the risk profile of a bank than other investors. Volz and Wedow (2011) note that investors exercise market discipline in the CDS market, as they find that prices are positively correlated with banks' risks. We expect capital and liquidity to correlate negatively with the bank CDS spreads as banks that are more capitalised and more liquid will have lower credit risk.

Finally, we add to the literature on the usefulness of CDS spreads in capturing bank risk positions. In particular, we add to the previous works by Hasan et al. (2015) and Kanagaretnam et al. (2016) on the applicability of market-based variables and accounting-based bank fundamentals to explain CDS spread changes. The accounting information used in those studies is mostly based on CAMEL[3] indicators in which only asset liquidity is considered. In our paper, we cover this gap as we use a large set of accounting variables and proxies for funding liquidity risk. Moreover, to the best of our knowledge works on CDS spread determinants do not include the effects of the sovereign debt crisis.

Our evidence suggests a bidirectional positive relationship between capital and liquidity, thereby supporting both the "financial fragility" and the "crowding out of deposits" hypotheses developed in theory (for more details see Section 2.1). Our evidence also confirms the ability of CDS spreads as a timely indicator of bank risk that can be used by regulators in early warning systems to monitor bank weaknesses. More specifically, we find that capital is an important determinant of CDS spread changes. However, funding liquidity risk is a determinant of CDS spread changes when it is above the minimum regulatory threshold and through the interaction with capital ratios.

The remainder of the paper is organised as follows. Section 2 reviews the main literature on the relationship between liquidity risk and capital and on the determinants of CDS spread changes in the banking sector. Section 3 describes the dataset and the variables included in the empirical analysis. Section 4 presents the methodology. Section 5 discusses the results. In section 6 we perform a battery of robustness checks. Section 7 concludes.

2. Literature review and hypothesis development

In our paper we link two strands of literature: the theories linking bank liquidity to capital (Section 2.1) and studies concerned in analysing the CDS spreads determinants of the banking sector (Section 2.2).

2.1 The relationship between liquidity and capital in banks

Several theoretical papers deal with the relationship between bank capital and liquidity creation. The theoretical discussion on this relationship has led to two main contrasting hypotheses: the "financial fragility/crowding-out of deposits" hypothesis and the "risk absorption" hypothesis.

[3] Camel rating system is supervisory rating system developed in the U.S. The acronym CAMEL stands for: Capital adequacy (C), Asset quality (A), Management quality (M), Earnings potential (E), Liquidity (L).

The former predicts that higher capital reduces liquidity creation. The financial fragility theory of Diamond et al. (2000; 2001), model a relationship bank that raises funds from investors to provide financing to an entrepreneur. In this model deposits are fragile and prone to runs. Increased uncertainty makes deposits excessively fragile and creates a role for bank capital. The quantity of capital reduces the probability of financial distress but hampers the benefits of liquidity creation of a bank. Thus, banks have to set the optimum level of capital that trades off the benefits of liquidity creation and the cost of distress. Moreover, Gorton and Winton (2000) develops the "crowding-out of deposits" hypothesis. The authors affirm that deposits are more effective liquidity hedges for investors than investments in equity capital. Higher capital ratios shift investors' funds from deposits to bank capital. Since deposits are liquid and bank capital is illiquid, there is an overall reduction of liquidity when capital is higher.

The alternative risk absorption hypothesis, which is directly linked with the risk-transformation role of banks, affirms that higher capital ratios enhance banks' ability to create liquidity. According to the theory: liquidity creation entails a risk. The more liquidity is created the greater is the likelihood and severity of losses associated with the transformation of short-term deposits into long-term illiquid assets. Since the role of capital is to absorb risk and expand banks' risk-bearing capacity, higher capital ratios enhance the ability of banks to create liquidity (Bhattacharya et al., 1993; Allen et al. 2004; among others).

Berger and Bouwman (2009) empirically test theories of the relationship between capital and liquidity creation. Using a sample of US banks during the period spanning 1993 to 2003, the authors develop a liquidity creation measure and investigate the effect of bank capital on liquidity creation. Their empirical results support both theories on the relationship between capital and liquidity. More precisely, they find that the relationship is positive for large banks when the liquidity creation measure considers off-balance sheet items and not significant when liquidity creation measure account only on balance sheet activities. The relationship is negative and significant for small banks using both liquidity creation measures.

Distinguin et al. (2013) by considering a sample of US and European publicly traded banks over the 2000-2006 period, analyse the impact of bank liquidity, measured on balance sheet items, on regulatory capital ratios. The results of the study suggest that banks decrease their regulatory capital when they create more liquidity or when they face higher illiquidity as defined in Basel III. Thus following the authors, capital is negatively related to bank liquidity creation.

However, the "financial fragility" hypothesis depends on the deposit insurance coverage. If insurance were complete, depositors would have no incentive to run on the bank in situations of uncertainty. Fungacova et al. (2010) empirically test how the introduction of deposit insurance affects the relationship between capital and liquidity. They find that the implementation of deposit insurance has a limited impact on the negative relationship between capital and liquidity creation.

On the empirical point of view, the causal relationship between capital and liquidity is difficult to grasp because it may be jointly determined. Hovarth et al. (2012) analyse the possible bi-causal relationship by employing a Granger causality test in a dynamic GMM panel estimator on a sample of Czech banks from 2000 to 2010. They show a negative relationship between capital and liquidity creation which confirms the financial fragility hypothesis. However, the authors observe also that liquidity creation Granger-causes a reduction in capital. This bi-directional negative causality suggests to consider the trade-off between financial stability reached by stronger capital requirements and the economic benefits related to liquidity creation. From a different perspective, Vazquez et al. (2015) and Chiaramonte et al. (2016) investigate the evolution of bank liquidity and leverage and their implications for financial stability. Vazquez et al. (2015) show the complementary nature of liquidity and capital in explaining bank fragility. The authors also find evidence of differences across bank size. More precisely, the smaller the bank the more inclined to fail on liquidity risk, while large banks are more inclined to fail due to insufficient capital buffers. While Chiaramonte et al. (2016), by analysing a sample of banks headquartered in Europe, argue that capital and liquidity plays a complementary role only for large banks, while for all banks the only significant determinant of bank failure is the Basel III structural liquidity ratio, which measures the mismatch in bank balance sheet.

The impact of regulatory intervention during crisis periods may also change the liquidity creation and risk-taking behaviour of banks. Berger et al. (2016) analyse the impact of regulatory interventions on bank liquidity creation. Using a dataset on 278 German banks over the period 1999-2009, the authors find that regulatory interventions and capital support reduce liquidity creation and bank risk taking.

Based on the empirical results of the papers discussed above, our hypothesis for the relationship between bank capital and liquidity are the following:

H1: Along the time span considered, which covers the financial and the sovereign debt crisis, the relationship between capital and liquidity is negative for large European banks.

Based on the presented literature, the hypothesis is disputed in both the theoretical and the empirical literature. On the theoretical point of view, the "financial fragility/crowding out of deposits" hypotheses seem to fit better on small banks. Larger capital markets are often quite segmented implying that a shift in bank deposits have a smaller impact on investor demand of equity and deposits. Therefore, the relationship between capital and liquidity creation should be positive for large banks as empirically demonstrated by Berger et al. (2009). In contrast, Distinguin et al. (2013) and Hovarth et al. (2012) claim that the relationship between capital and liquidity creation should be negative also for large banks. In addition, Vazquez et al. (2015) and Chiaramonte et al. (2016) demonstrate the complementary role of liquidity and capital in explaining bank fragility. We believe that the financial and the sovereign debt crisis and the following regulatory interventions, pressured banks in considering liquidity and capital as complementary determinants. With the result, that banks strength their capital when facing liquidity concerns.

2.2 The influence of liquidity risk and capital on CDS spread changes

The leverage ratio and the higher structural mismatches in bank balance sheet have been the key factors in the propagation of the crisis. Therefore, the logical follow-up question then is: how CDS spread changes, which reflect the market probability of failure, are affected by the relationship between liquidity and capital.

To derive a testable hypothesis of this question we rely on the literature explaining CDS spread determinants. The specifications of CDS spread models are based on the theory developed for corporate bond credit spread (Merton, 1974). However, structural variables have limited power in explaining credit spread changes (Collin-Dufresne et al. 2001). As a matter of fact, recent studies (Collin-Dufresne et al. 2001; Blanco et al., 2005; Ericsson et al. 2009) extends structural models by including some additional factors such as stock market returns and the slope of yield curve, in response to the so-called credit spread puzzle. Works on CDS spread determinants (Galil et al., 2014; Das et al., 2009; among others) generally exclude banks from the empirical investigation, due to their particular asset structure that exacerbates the credit spread puzzle. As a consequence, only a few studies are devoted on the determinants of CDS spread changes in the banking sector. Annaert et al. (2013) used structural variables to explain CDS spread changes of 32 listed euro area banks. The authors found that the determinant of CDS spread changes vary across time, so the models have to be re-estimated frequently. The authors also highlight the importance of market liquidity and market wide factors in addition of structural variables in explaining CDS spread changes.

Despite the popularity of market-based default metrics, the empirical literature on bank-failure (Cole and White, 2012; Berger et al., 2016; DeYoung and Torna, 2013; Altunbas et al., 2011; among others) suggests that accounting information has an important role in predicting distress. Thus, a hybrid model using both accounting ratios and market based variables predict to a larger extent CDS spread changes. Hasan et al. (2015) investigate the effect of both structural variables and balance-sheet ratios on bank CDS spreads, while controlling also for market factors. The authors find that balance-sheet ratios increase the explanatory power of structural variables; furthermore, they find that the impact of leverage and asset quality on CDS spreads is stronger during turmoil periods. Chiaramonte et al. (2013) and Okter-Robe et al. (2010) find that CDS spread reflect the credit risk captured by some balance sheet-ratios on a sample of European banks. In a related paper, Kanagaretnam et al. (2016) test the relevance of accounting information and loan/securities and investments by type in explaining CDS spread changes. The authors find that risky ABS securities and real estate risk was a major risk for US bank holding companies reflected in CDS spread changes. Liu et al. (2015), while controlling for structural variables and accounting indicators, find that deposit insurance has an adverse effect on Bank CDS spreads. They also demonstrate that the adverse effect of deposit insurance is greater when banks have poor asset quality and liquidity.

All the previous mentioned studies provide evidence that leverage plays a pivotal role over the stability of a banks, but largely ignore liquidity risk and off-balance sheet exposure. Although studies focused on CDS spread changes include proxies for liquidity, they mostly focus on CAMEL[4]-based asset side liquidity or the general funding liquidity. Maturity transformation risk is largely ignored, just as off-balance sheet exposures which are important determinants of banks liquidity and leverage respectively. Moreover, the joint relationship between liquidity risk and leverage is also ignored. Therefore, by taking in consideration these components we are able to extend the literature on banks CDS spread determinants. Paring these results with the findings of bank default studies, showing that capital and liquidity risk posed a serious threat to bank probability of failure (Chiaramonte et al. 2016; Vazquez et al., 2015), leads us to the following hypothesis:

H2: The interplay between capital and liquidity contribute to CDS spread changes.

Based on the empirical evidence presented above, we believe that the empirical investigation of CDS spread determinants during the recent crisis might provide support for the hypothesis.

[4] Camel rating system is supervisory rating system developed in the U.S. The acronym CAMEL stands for: Capital adequacy (C), Asset quality (A), Management quality (M), Earnings potential (E), Liquidity (L).

3. Data and descriptive statistics

3.1 Data and sample selection

Our sample consist of Euro area banks for which CDS contracts are listed. The selection of the banks is driven by the availability of data on CDS quotes on Bloomberg Professional Service[5]. We obtain CDS spread series on 5-year senior debt contracts for 38 banks at quarterly frequencies over the years 2005-2015. Table (1) lists the bank included in our study. To ensure that CDS spread changes reflect meaningful information on bank credit risk, we impose strict liquidity criteria. More precisely, we retain only CDS spread changes during a certain quarter only if at least 80% of observations are non-zero during the quarter.

[Insert table 1 about here]

We gather quarterly balance sheet data from Bloomberg financial service, while macroeconomic data is from the World Bank Database. Table (2) show the descriptive statistics of all the variables used in this study.

The decision to focus on CDS spreads had a decisive impact on sample size, given that only a limited number of banks have listed CDS contracts. However, the possibility of rely on quarterly data rather than annual data make available a higher number of observations for our analysis.

[Insert table 2 about here]

3.2 Capital and liquidity risk proxy variables

The target variables of our analysis are capital ratios and liquidity proxies defined in Basel III. Capital requirements are usually set as a proportion of risk weighted assets. The Basel II total regulatory capital ratio is defined as the sum of the core (Tier 1) and the supplementary (Tier 2) capital on risk weighted assets. The supplementary capital contains hybrid instruments, therefore for deeper inside we consider the total common equity tier 1 (CET 1), which is the ratio of total shareholder funds on risk weighted assets. However, the risk weighted calculation under Basel II rules might not reflect the actual risk. Capital measures based on non-risk weight assets may have been considered as more meaningful for stock participants (Demirgüç-Kunt et al., 2013a) and good predictors of bank failure (Lev and Huang, 2009). In line with these studies and with the new Basel

[5] Bloomberg relies on Credit market analysis (CMA) for pricing credit derivatives. CMA receives quotes for credit instruments from 30 buy-side firms, including major investment banks, hedge funds and asset managers.

III regulation, we measure bank capital as the ratio of equity to total assets. Moreover, large banks might increase their risk exposure through the management of their off-balance sheet items, in order to take in consideration this effect, we add another measure of leverage defined as the ratio of equity to total assets and off-balance sheet exposures, in line with the Basel III leverage ratio. Regulatory capital formulations refer to measures of capital at book value, however banks could base their liquidity risk management practices also on market measures of capital. For example, banks might target a market value of capital below which the bond market starts charging a risk premium. Or they might target both book and market value of equity needed to pursue future acquisition strategies. For this reason, we include also the ratio of market capitalization to total market value.

The banking literature as developed some synthetic liquidity indicators that attempt to grasp the liquidity of bank assets and liabilities (Deep and Schaefer, 2004; Berger and Bouwman, 2009; BIS, 2009). The liquidity creation measure developed by Berger and Bouwman (2009) is closely related to the regulatory measure of funding stability. Both indicators try to capture the portion of illiquid assets financed with short-term funding, moreover both are measured giving a weight of the balance sheet items depending on their stability. Since, we would measure liquidity in a way consistent with Basel III, we rely on the NSFR. The NSFR is the defined as the ratio of available stable funding to required stable funding. More precisely, the NSFR is a ratio between the weighted sum of the different type of liabilities (L_i) and assets (A_J):

$$NSFR = \frac{\sum_i w_i L_i}{\sum_j w_j A_j} \quad (1)$$

The weights w_i are defined by the Basel committee and reflect the stability of the balance sheet components. In 2014 the committee as issued a revision of the weights of the NSFR previously defined in the 2010 version. Due to the evolving nature of the Basel III liquidity standard we calculate two versions: NSFR 2014 based on the last technical document (BCBS, 2014) and NSFR 2010 based on the original document (BCBS, 2010b). The necessary granularity of the bank assets and liabilities to calculate the NSFR is not provided in Bloomberg professional service. In particular, we cannot split the loan portfolios according to their maturity and types, which under Basel III entails different weights. Following a conservative approach, we require that the portfolio of loans requires an overall weight of 0.85. Furthermore, we cannot split securities in government bonds and other securities, thus, following a conservative approach, we use a weight of 0.5, which is within the weight proposed in Basel III for other securities items. The description of each capital and liquidity proxy variable with its calculation is provided in Table (3).

[Insert table 3 about here]

4 Empirical methodology

4.1 The relationship between liquidity risk and capital Econometric Methodology

We first analyse the relationship between liquidity and capital using the set of proxy variables defined in the previous section. This analysis investigates the contribution of liquidity in explaining bank capital ratios. Berger and Bouwman (2009) and Distinguin et al. (2013) claim that bank capital might also be a determinant of bank liquidity creation. For example, it is sure that requiring a bank to hold more high-quality liquid assets make it safer and less need of capital. To deal with simultaneity that create endogeneity concerns, we use a simultaneous equation model as in Distinguin et al. (2013).

In the first equation, we regress alternatively the different formulations of capital on a set of bank specific and macroeconomic factors, to which we add liquidity measures. In the second equation, we regress the two liquidity formulations on a set of independent variables representative of: bank specific factors, the macroeconomic environment and the European Central Bank policies. We employ a simultaneous equations model, where the system of equations is estimated via GMM:

$$\begin{cases} Capital_{i,t} = \alpha_{i,t} + \beta Liquidity_{i,t} + \sum_{k=1}^{K} \varphi_k DC_{ki,t-1} + \sum_{j=1}^{J} \varphi'_j DC_{ji,t-1} + \varepsilon_{i,t} \\ Liquidity_{i,t} = \partial_{i,t} + \delta Capital_{i,t} + \sum_{m=1}^{M} \gamma_m DL_{mi,t-1} + \sum_{n=1}^{N} \gamma'_j DL_{ni,t-1} + \vartheta_{i,t} \end{cases} \quad (1)$$

$Capital$ and $Liquidity$ correspond respectively to the capital and liquidity proxies. $DC_{ki,t}$ and $DL_{mi,t}$ are the kth and the mth exogenous determinants of capital and liquidity. $DC_{ji,t}$ and $DL_{ni,t}$ are the mth

and the nth endogenous determinants of capital and liquidity[6]. The equations of the system (1) are estimated simultaneously controlling for the endogeneity of the independent variables in a GMM approach. The GMM estimation method has two advantages compared to the two-stage least squares: it is robust to the distribution of errors and it accounts for heteroskedasticity of errors. Moreover, as shown by Arrellano et al. (1991) and Blundell et al. (1998) the benefits of GMM estimation become more apparent when applied on a system of equations.

[6] Endogeneity tests are performed through the Hausman test by considering each equation of the system individually. Endogenous variables are replaced by their one-quarter lagged values. We replace all the bank specific variables with their one-quarter lagged values.

The selection of bank specific and macroeconomic variables of equation (1) is based on the literature on bank capital and liquidity. In the capital equation, we embrace the following variables: profitability, asset risk, bank charter value, size and the macroeconomic environment. We include profitability in the capital equation because raising additional capital is costly. According to the pecking order theory funding extra capital is the most expensive financing choice, hence it may be easier increase capital through retained earnings and weaker dividend payments (Flannery and Ragan, 2008). Increase capital buffers is relatively easy when earnings are high, thus we expect a positive relation between profitability and capital ratios. Asset risk is also included in the capital equation. According to Jokipii et al. (2008), Berger et al. (2008) and Flannery et al. (2010) banks with risky portfolio generally hold more capital. Because bank capital can be viewed as a buffer for assuming losses for risky assets. The mentioned studies considered the ratio of the loan loss provision to total assets as proxy for banks asset risks. We expect a negative sign of the coefficient of this variable in the determination of bank capital. Banks with higher chartered values might raise capital more easily and cheaply than their peers, implying less need of capital buffers (Berger et al.; 2008). On the contrary, Gropp et al. (2010) suggests that bank reputation and chartered value should be protected by larger capital buffers. We use the ratio of market to book value as an indicator of chartered value. We do not have predictions of the sign of the variable in the capital regression framework. Bank size is included to capture size effects on bank capital ratios. According to Berger et al. (2008), large banks are incline to hold lower capital buffer since large banks tend to be more diversified and better able to manage their risky assets. On the contrary, large institutions are constrained to hold more capital due to their systemic relevance, hence the relationship could be negative. We use the logarithm of total assets as a proxy of bank size. We do not have a prediction for the sign of the coefficient of this variable in the capital regression. Capital buffers are also related to the economic cycle. According to the literature (Shim, 2013; Jokipii and Milne, 2008; 2011), bank capital is countercyclical. Banks tend to decrease their capital buffers during economic booms and increase them during economic downturns. We include the growth of real gross domestic product as a proxy of the business cycle. We expect a negative sign of the coefficient of this variable in the determination of bank capital buffers.

In the liquidity equation, we include the following variables: size, structural funding risk, central bank net lending facilities and the macroeconomic environment. We introduce size in our liquidity regression framework because size differences among banks affect the degree of liquidity creation (Berger and Bouwmnan, 2009). Moreover, size could be an indicator of market power, which improve the ability of bank to create liquidity from their balance sheet exposures. We use the logarithm of total assets as a proxy for bank size. We presume a negative sign for the coefficient of this variable in the determination of bank liquidity. Following Rauch et al. (2009) and Distinguin et al. (2013) when central bank's policy rates decline credit supply to financial institutions increases, which positively affect bank liquidity. To uncover this effect, we use the ECB net lending to credit institutions index (TLCIECB Index). We expect a positive sign for the coefficient of this variable in the determination of bank liquidity. In line with Distinguin et al. (2013) we introduce a proxy variable for liquidity pressures in the interbank market. We consider the spread between the one-month interbank rate and the policy rates as a measure of liquidity pressures on the interbank market. We expect that higher values positively affect bank liquidity. The macroeconomic control variable for bank liquidity is based on Dietrich et al. (2014). In particular, as in the capital regression we include the growth of real gross domestic product. We expect a negative sign of the coefficient of this variable also in the determination of bank liquidity. Finally, we include the logarithm of CDS changes to control for potential changes in the management of liquidity risk and capital in times of market stress.

Before the crisis, potential threats related to liquidity and capital were widely ignored and banks were incentivized to rely on short-term funding rather than more stable funding sources. After the crisis, lack of liquidity and capital forced them to shrink their balance sheets, which would have had a beneficial effect on Capital and NSFR.

4.2 Factor model CDS spreads

To examine the importance of the relationship between liquidity risk and capital, we ask whether both risks affect credit spread changes. To do so, we run a panel data fixed-effect regression model. Each regression uses the logarithm of quarterly CDS spreads as a dependent variable. In the regressions, we use alternatively all the capital and liquidity formulations considered in the study. Independent variables include bank structural variables, CAMELS indicators and macroeconomic controls. The model is as follow:

$$CDS_{i,t} = \alpha + \beta Capital_{i,t} + \gamma Liquidity_{i,t} + \delta Y_{i,t} + \lambda Z_{j,t} + \vartheta_i + \vartheta_t + \varepsilon_{i,t}$$

Where CDS is the natural log of CDS spread for bank *i* at year *t*; *Capital* and *Liquidity* identifies alternatively the five formulations of capital and the two formulations of the net stable funding ratio.

Y represent a set of bank specific covariates. *Z* represent structural variables and country level controls. ϑ_i and ϑ_t are bank and time fixed effects, respectively. Standard errors are clustered at the bank level.

To select bank specific covariates, we follow Hasan et al. (2015), Chiaramonte et al. (2011), Okter-Robe et al. (2010) and Kanagaretnam et al. (2016). More precisely, we include the ratio of non-performing loans to total loans as a measure of asset quality, the return of total assets as a measure of performance, the interest income over total income and the loans to total assets as a business model control, the log of total assets as a measure of size. On our regression model, we also control for structural variables and market wide factors. In particular, we control for asset volatility using the 60 days' historical standard deviation of bank's daily equity return in a particular quarter. The selection of this variable is based on Ericsson et al. (2009), Campbell et al. (2003) and Galil et al. (2014). To reduce the credit-spread puzzle we include two market wide factors, which accounts for market expectations and general business climate improvements. To control for market expectation about future conditions in the financial market, we consider the difference between the 10-year redemption yields and the 1-year Euribor rate. While we include the return of the Eurostoxx 600 stock index as a proxy of general business climate improvements. The selection of the market wide factors is based on Ericsson et al. (2009), Collin-Drufesne et al. (2001), Annaert et al. (2013) and Campbell et al. (2003).

5. Results

5.1 The relationship between capital and liquidity: Results

To test the impact of liquidity on capital we estimate the simultaneous equation system defined in (1). In the capital equation, we regress several proxies of bank capital on a set of determinants identified in the previous section. We use alternatively three classes of formulations of capital: the leverage ratio defined in Basel III, the risk-weight capital ratios defined in Basel II and a market based measure of capital. The aim is to examine whether banks manage differently the various components of capital. In the liquidity equation, we regress the proxy of liquidity on a set of determinants described in the previous section. In this regression, we use alternatively the two configurations of the inverse of the Net stable funding ratio as a dependent variable. After having tested endogeneity with the Hausman test (un-displayed results), we replace all the bank specific variables in the two equations with their one quarter lag[7].

Table (4) shows the regression results with the Basel III formulations of capital. The results show that Basel III capital ratios have a positive bidirectional relationship with the NSFR. The higher the NSFR (the higher the liquidity of a bank) the higher the plain capital ratios. This result supports the "financial fragility structure" and the "crowding out of deposits" hypotheses. According to the

[7] Regarding liquidity and capital, which are not lagged in the simultaneous equations, we deal with endogeneity problems by adopting the GMM estimation method.

first, higher capital is associated with less monitoring, which reduced liquidity creation (Diamond and Rajan, 2000; 2001), while the second claim that higher capital could crowd out deposit and reduce liquidity creation (Gorton and Winton, 2000). The bidirectional relationship appears stronger, in column (1a) and (1b) where we take into account the off-balance sheet exposures in the leverage ratio. This result suggest that large banks manage liquidity risk with sophisticated strategies that involve off-balance sheet exposures, therefore the simple ratio of equity to total assets is less useful in understanding the relationship between capital and liquidity.

[Insert table 4 about here]

In table (5) we analyse the relationship between liquidity and capital with risk based and market based measures of capital. Columns (3a, 3b, 4a, 4b) of table 5 show the equation results with the different regulatory capital formulations: CET 1 and total capital ratio. We find that the NSFR coefficient is significantly positive only when the total capital ratio is the dependent variable. These results are in line with Distinguin et al. (2013), who claims that instead of strengthening their solvency standards, banks reduce their regulatory ratios when they face higher funding liquidity risk. We believe, that the relationship between the regulatory capital ratios and the NSFR is not significant because risk-based capital requirements do not represent the real leverage of a bank and thus the strict interplay between capital and liquidity management.

In columns (5a) and (5b) we consider the market based formulation of capital. Since market capitalization is cyclical (Adrian et al., 2014) the coefficients of the NSFR in the capital equation is negative. Thus, we can conclude that we find again a positive relationship between capital and liquidity, similar to that observed in table 4.

[Insert table 5 about here]

To wrap up our results, we support the "financial fragility" and the "crowding out of deposits" hypotheses when we consider the Basel III leverage ratio with off-balance sheet exposures, the plain equity to total asset ratio and the market based definition of capital, while we do not find evidence of a relationship between capital and liquidity when we rely on regulatory capital ratios. These result, implies that the definition of capital is important for understanding the connections between capital and liquidity for large financial institutions.

Regarding the other determinants of capital and liquidity, most of the findings are consistent with our predictions and those obtained in previous studies. The most relevant factors of the capital ratios are credit risk, size and GDP growth. The credit risk variables are significantly negative, suggesting that banks strength their capital ratios when they face higher credit risk. The logarithm of total assets has a negative sign suggesting a negative association between capital ratios and size. Regarding the macroeconomic control, we find a countercyclical behaviour of regulatory capital ratios, while the other definitions of capital buffers seems to be cyclical.

Focusing on the control variables in the liquidity equation, all the variables are positive and statistically significant. In contrast to the literature that covers the period before the global financial crisis (Berger and Bouwman, 2009; Distinguin et al., 2013) we find a positive association between size and the GDP growth with liquidity. As expected the coefficients of the spread in the one-month interbank rate is positive suggesting that shocks in the interbank market constraints banks to increase their liquidity. Moreover, the ECB liquidity injections increases bank liquidity during stressed market periods.

Finally, we find a positive and significant sign of the lagged CDS spread variable in both the capital and liquidity equations. The result supports our hypothesis that during stressed market periods, banks try to increase liquidity and capital to overcome financial market turmoil.

5.2 The impact of liquidity and capital on CDS spread changes

To examine the importance of liquidity risk and capital, we ask whether both risks affect credit spread changes. The meaningful relationship between those variables discussed in section 4 indicate a joint management of liquidity and capital in banks. If this is true we should find that capital and liquidity risk contribute to CDS spread changes, as stated in H2.

After the results regarding the relationship between liquidity risk and capital presented in the previous section, we believe that there is one main theoretical reason supporting our hypothesis. Firstly, literature on bank capital as well as literature on liquidity risk has established that both variables have strong implications for bank's PD and financial stability. Secondly, the raising literature on liquidity creation and bank capital have highlighted the complementary nature of these two variables and the subsequent implications for financial stability and credit risk of financial institutions. We therefore have strong reasons to test whether or not capital and liquidity risk determines CDS spread changes.

As can be seen from table (6) we run equation (2) in ten different settings, using alternatively all the capital formulations and both versions of the NSFR. More precisely, we run the regression with Basel III formulations of capital (models 1 to 4), the Basel II risk based measures of capital (models 5 to 8), as well as the market based measures of capital (model 9 and 10).

[Insert table 6 about here]

The Basel III capital variables enters with positive and statistically significant coefficients. As regarding the risk based measures of capital, only the total capital ratio has a positive and significant sign. What emerges is the limitation of the CET1 ratio in measuring bank capitalization. This could be related by two reasons. The limited variation of the CET1 among banks and time[8], and the limited sensitivity of risk-weigh capital ratios to market changes conditions as shown by Demirgüç-Kunt et al. (2013a). Finally, the market value of capital has a negative and significant sign at the 10% level. The positive sign of the capital ratios is consistent with the findings of Demirgüç-Kunt et al. (2013b) and reflects the too-big to fail status of the large banks comprised in our sample.

The liquidity proxy variables are positive and insignificant in all the regression models, suggesting that funding liquidity risk is not a determinant of CDS spread changes for large European banks. However, the lack of significance of the variable could be explained in different ways. Large banks are more inclined to fail due to credit risk and banks with higher credit risk might reduce maturity mismatches in order to reduce the probability of default (Imbierowicz et al., 2014). In addition, during the crisis banks with ratios of NSFR closed to the target might have decreased lending to manage liquidity risk[9]. To shed further light into the matter, in the next sections we add a dummy variable to analyse if values of NSFR below one is a priced risk factor. Then we also analyse if liquidity ratios below the minimum requirement affect CDS spread changes through their interaction with capital measures.

We found a positive relationship between asset quality and bank CDS spreads and a negative one between performance and bank CDS spreads. The signs of these two variables reveals that the probability of default tends to increase with poor-quality loan portfolio and/or lower returns on assets. These outcomes confirm the findings of Chiaramonte et al. (2011) and Hasan et al. (2015). The share of interest income over total income appears to increase CDS spreads. The sign of the coefficient is in line with Demirgüç-Kunt et al. (2013b) who highlighted that fee income is negatively related to CDS spreads. However, this sign is in contrast with the literature on bank failure, DeYoung et al. (2013) demonstrates that banks with a higher level of fee-income are more inclined to fail. In terms of the asset structure, both bank size and the ratio of loans to total assets are positively related to CDS spread changes. The sign of the size variable is consistent with the hypothesis that large banks have been considered by the market as "too big to fail" and thus more likely to be rescued (Demirgüç-Kunt et al., 2013b; Tarashev et al., 2009; Volz and Wedow, 2011). While the magnitude and significance

[8] All the banks comprised in our sample, also the most riskier, have a CET1 ratio above the minimum regulatory requirement.
[9] We test the proposition in the robustness test section.

of the coefficient of bank loans is in line with the literature on bank default. As stated by Altunbas et al., (2011) the loan exposure is influenced by national factors; thus, in a weak macroeconomic environment it is likely that commercial banks have a higher probability of default.

The equity volatility variable has coefficients consistent with theory (Merton, 1974) and statistically significant at the 5% level. As for the market-wide variables, the Eurostoxx and the Term spread variables both have coefficients expected and significant. In particular, the performance of the Eurostoxx has a negative significant sign, indicating that a deterioration in general business climate increases the probability of default and recovery rates, thus increasing CDS spread. While, the term spread has a positive and significant sign. This is related to the increase in peripheral European government 10-year yields during the sovereign crisis, which obviously affected sovereign and bank CDS spreads.

5.2.1 Are threshold effects at play?

While all the banks comprised in our sample meet the minimum required capital target, some banks do not meet the liquidity requirements while other have a NSFR well above the minimum required. To gauge the potential threshold effect, we add a dummy variable which takes value one in case of the NSFR is below the minimum required and zero otherwise. The results of the investigation are sown in table (7). We find a positive and significant sign of the last version of the NSFR in all regression formulations, while the first version of the NSFR is not significant only when we use the Basel III leverage ratio (column 1). The positive and significant sign of the NSFR could be due to the fact that banks with higher credit risk might reduce lending to keep liquidity risk low in order to maintain the total level of default risk limited[10]. On the contrary, banks with low credit risk do not necessarily have to manage both risks jointly because the overall risk is limited (Imbierowicz et al., 2014). Although the NSFR recommendations will became effective in the 2018, the positive and significant sign of the dummy variable in all the regression results suggest that the credit derivatives market prices the risk of having higher liquidity mismatches.

[Insert table 7 about here]

5.2.2 Model with indirect effects of liquidity risk

In this subsection, we assume that liquidity ratios below the minimum requirement affect CDS spread changes through their interaction with capital measures. Table (8) reports the estimation results

[10] The correlation matrix shows a positive correlation between the NSFR and the ratio of NPL to total loans, confirming our interpretation of the sign of the coefficient. In the robustness section, we demonstrate the proposition with an ad hoc regression model.

for models with indirect effect of liquidity risk. The specifications (1) to (10) add an interaction term between the capital ratio and the dummy variable that takes value one if the NSFR is below one.

[Insert table 8 about here]

The results suggest that the interaction between capital and liquidity risk affect bank probability of failure and thus CDS spread changes. In this setup, the NSFR is not significant in all the regression models, while he interaction terms are all positive and significant, with the exception of those with the equity to total assets proxy of capital (column 3-4). The sign and the coefficients of the control variables remain roughly equal in terms of magnitude and significance, confirming the findings of the previous regression models. Overall, these results show that the interaction between capital and liquidity affect the probability of failure when liquidity is below to the minimum regulatory target.

6. Robustness tests

6.1 Robustness bank capital and liquidity

To test the reliability of our results on the relationship between bank capital and liquidity, we perform a battery of robustness checks. First, since the loan loss provision could be a discretionary tool to smooth earnings over time (Leventis et al., 2011), we redo the simultaneous equations system using an alternative credit risk measure. More specifically, we rely on the ratio of loan loss reserve to non-performing loans as a proxy of resources set aside to cover expected credit losses. The idea is that, if an institution lacks sufficient loan loss reserve to cover loans charged-off, the excess charge-offs will be covered with capital. We expect a positive for this variable. The results are consistent with those previously obtained with the loan loss provision to total assets. The alternative credit risk measure has a positive and significant sign in all regression formulations, using alternative liquidity and capital variables (Table 9).

We also examine the robustness of our results by considering two alternative liquidity proxies. We use the "liquidity transformation gap" (LT gap) defined in Deep and Schaefer (2004) and the "cat-fat" liquidity creation measure developed in Berger and Bouwman (2009). The LT gap is the difference between liquid liabilities and liquid assets held by a bank divided by its total assets, thus the higher the coefficient the higher the illiquidity of a bank. The "cat-fat" liquidity creation indicator assigns weights to different asset and liabilities based on their liquidity as defined in Berger and Bouwman (2009), similarly to the liquidity transformation gap the higher the coefficient the higher the illiquidity of a bank. Again, our checks are consistent with those previously obtained with the

NSFR variables (Table 10). Finally, according to Dietrich et al. (2014) business models have also an impact on the NSFR. Given the higher weights given on loans and deposits in the denominator and numerator of the NSFR respectively, financial institutions focused on the lending/deposit taking business might have a higher NSFR than banks with a higher proportion of investment bank activities. We control for business models by adding the ratio of interest income to total income in the liquidity regression. The results are consistent with those obtained previously (Table 11). Moreover, the interest income to total income variable has a positive and significant sign in line with the findings of Dietrich et al. (2014).

6.2 Robustness CDS spread changes

Several possible explanations are consistent with the positive relationship between the NSFR and CDS price changes. As discussed, during the crisis banks with higher credit risk might reduce lending to keep liquidity risk low in order to maintain the total level of default risk limited. Moreover, banks with higher illiquid assets on their balance sheet might have reduced lending to increase asset liquidity. To test these hypothesis, we estimate the following panel data fixed effect model. We regress the NSFR on five key drivers of liquidity risk management: (1) the level of non-performing loans, (2) the loan growth variable, (3) deposits as a fraction of total funding, (4) the Basel III leverage ratio. We also comprise asset size to proxy for many other sources of heterogeneity between banks. To gauge the effect of the crisis we interact the variables with the interbank pressure defined as the spread between the one-month interbank rate and the policy rates. We also control for time fixed effect with quarterly time dummies. The selection of the variables used is based on Cornett et al. (2011). Table (12) reports the regression results. We find evidence to support our statements. Banks with higher credit risk tend to increase liquid assets in order to maintain the overall risk limited. On the contrary, banks with higher NSFR ratios and lower credit risk continue to lend during the crisis period.

To further check the results of our regression models, we gauge a set of robustness tests. First, we redo our regressions with alternative balance sheet ratios. More specifically, we use: the loan loss provision to total assets as a measure of asset quality, ROE for profitability. The diagnostic estimation confirms the results of the baseline regressions (Table 13, 14 and 15). In a not displayed check, we look at the impact of an alternative clustering setup. We clustered standard errors at the country level instead of the bank level and we confirm the results obtained previously. Finally, we also perform collinearity checks and correlation analysis among explanatory variables and do not find multicollinearity problems for all the regression reported[11].

[11] Results not displayed for reasons of brevity.

7. Conclusions

Capital and liquidity and are two important factors for bank survival. This study investigates the connections between these factors and the impact on market default probabilities on a sample of EU banks over the period 2005 to 2015. Using various configurations of capital and liquidity consistent with the new Basel III regulation, we find a bidirectional positive relationship between capital and funding liquidity risk. The results also indicate the importance of defining capital and liquidity proxies. More precisely, we highlight the importance of considering off-balance sheet exposures in understanding the connections between capital and liquidity. Our results support the "financial fragility/ crowding out of deposits" hypotheses developed in Diamond et al. (2000; 2001) and Gordon and Winton (2000) respectively, and are consistent with the empirical findings of Distinguin et al. (2013) and Horvath et al., (2014). Since the complex relationship between capital and liquidity and the importance of both factors for financial stability, we question if these are price risked factors in the CDS market. We find that capital is an important determinant of CDS spread changes, while the NSFR becomes significant only when the ratio falls below the minimum regulatory threshold. We also document that the interactions of both variables significantly determine bank's market probability of default.

Our results have several interesting policy implications. Although we cast doubts on the accuracy of Basel II risk weighted capital ratios, due to the sophisticate liquidity risk management of large banking institutions through off-balance sheet instruments. We support the need to implement minimum liquidity ratios concomitant with capital ratios, as we show that are closely related to each other. We also provide evidence of market discipline in CDS spreads, as we show that bank risk correlate positively with bank's market probability of default. The derivative market evaluates changes in leverage and funding liquidity risk and incorporate those factors promptly into bank's CDS spreads. Therefore, monitoring of such securities generates signals that may convey useful information to supervisors.

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Table 1
List of banks included

Bank	*Country*	*Bank*	*Country*
Erste Group Bank AG	Austria	DNB ASA	Norway
Raiffeisen Bank	Austria	Banco Comercial Portugues	Portugal
Dexia	Belgium	Banco Bilbao Vizcaya Argentaria SA	Spain
Danske Bank A/S	Denmark	Banco Popolare	Spain
BNP Paribas SA	France	Banco Sabadell	Spain
Credit Agricole SA	France	Banco Santander SA	Spain
Natixis	France	Nordea Bank	Sweden
Societe General	France	Skandinaviska Enskilada Banken	Sweden
Commerzbank AG	Germany	Svenska Handelsbanken AB	Sweden
Deutsche Bank AG	Germany	Swedbank AB	Sweden
IKB Bank	Germany	Credit Suisse Group AG	Switzerland
Alpha Bank A.E.	Greece	UBS AG	Switzerland
Bank of Ireland	Ireland	Cooperatieve Centrale Raiffeisen	The Netherlands
Banca Popolare di Milano	Italy	ING Bank NV	The Netherlands
Banca Monte Paschi di Siena	Italy	Barclays Bank PLC	UK
Intesa Sanpaolo SPA	Italy	HSBC Bank PLC	UK
Mediobanca SPA	Italy	Lloyds Bank PLC	UK
UBI Banca	Italy	Royal Bank of Scotland PLC/The	UK
Unicredit SPA	Italy	Standard Chartered Bank	UK

This table of the banks included in our analysis. For each bank we also report their home country.

Table 2
List of variables used together with their definition and summary statistics

Variable	Definition	Mean	Std. Dev.	Min	Max
Basel III leverage	The ratio of tangible equity to total assets and off-balance sheet exposures	0.047	0.021	0.016	0.083
Equity to Total Assets	The ratio of tangible equity to total assets	0.056	0.041	0.020	0.093
CET1	The ratio of common equity to risk weighted assets	0.161	0.056	0.049	0.188
Total Capital	The ratio of Tier 1 and 2 to risk weighted assets	0.140	0.036	0.096	0.208
Market Capital	The ratio of equity market value to total market value of assets	0.077	0.109	0.002	0.404
NSFR_10	The ratio of available stable funding to required stable fined as define by the Basel III document of December 2010	1.048	0.218	0.368	2.158
NSFR_14	The ratio of available stable funding to required stable fined as define by the Basel III document of December 2014	1.072	0.223	0.381	2.190
ROE	Net income to total equity capital	0.081	0.151	-0.08	0.223
LLP/TA	The ratio of loan loss provisions to total loans	0.236	0.306	0.001	0.016
MKT_BV	Total Market Value to Book Value	0.883	0.205	0.546	1.201
Size	Logarithm of total assets	5.712	0.563	4.497	6.564
GDP Growth	Percentage of GDP growth	0.004	0.023	-0.09	0.053
Interbank Spread	Spread between the one-month interbank rate and the policy rates	0.016	0.0163	-0.01	0.008
ECB Lending	ECB net lending to credit institutions	2.649	0.121	2.206	2.825
LLR_NPL	Loan loss reserve to non-performing loans	0.736	0.951	0.339	1.919
Income diversification	Interest income over total income	0.530	3.590	0.227	0.989
NPL/TL	The ratio of non-performing loans to total loans	0.059	0.076	0.004	0.176
ROA	Return on Assets	0.005	0.048	-0.008	0.128
Loans/TA	The ratio of loans to total assets	0.530	0.179	0.195	0.786
Equity Volatility	60 Days standard deviation of bank stock returns	40.55	31.25	15.26	92.77
Euro Stoxx	The natural logarithm of the Eurostoxx 600 index	2.467	0.081	2.24	2.599
Term Spread	The difference between the 10-year government bond yield for each Bank country and the 1-year Euribor/Libor rate.	1.629	2.446	-0.64	6.076
CDS spread	The Natural Logarithm of CDS spread changes	1.933	0.555	0.528	3.360

This table contains the description and the descriptive statistics of all variables used in the paper's analysis.

Table 3
Bank capital and liquidity risk proxy variables

Category	Proxy	Calculation	Definition
Risk-Unweighted Capital Ratio	Basel III Leverage	$\frac{Tangible\ Equity}{Total\ Assets + Off\ Balance\ sheet\ Exposure}$	The ratio of tangible equity to total assets and off-balance sheet exposures
Risk-Unweighted Capital Ratio	Equity to Total Assets	$\frac{Tangible\ Equity}{Total\ Assets}$	The ratio of tangible equity to total assets
Regulatory Capital	CET1	$\frac{Common\ Equity}{RWA}$	The ratio of common equity to risk weighted assets
Regulatory Capital	Total capital	$\frac{Tier\ 1 + Tier\ 2}{RWA}$	The ratio of Tier 1 and 2 to risk weighted assets
Market Capital	Market Capital	$\frac{Equity\ Market\ Value}{Total\ Market\ Value}$	The ratio of equity market value to total market value of assets
Liquidity	NSFR_10	$\frac{Equity + 0.95 * Stable\ deposits + 0.90 * Customers\ deposit + 0.50 * Short\ term\ borrowing}{0.5 * Marketable\ securities + 0.85 * loans + 1 * other\ assets^{12} + 0.05 * Off\ balance\ sheet\ items}$	The ratio of available stable funding to required stable fined as define by the Basel III document of December 2010.
Liquidity	NSFR_14	$\frac{Equity + 0.90 * Stable\ deposits + 0.80 * Customers\ deposit + 0.50 * Short\ term\ borrowing}{0.50 * Marketable\ securities + 0.85 * loans + 1 * other\ assets + 0.05 * Off\ balance\ sheet\ items}$	The ratio of available stable funding to required stable fined as define by the new Basel III document of October 2014

This table contain the description and the calculation methodology of our target variables: capital and funding liquidity risk.

[12] Other assets are the sum of: the reserve for impaired loans, Non-earning assets (Total assets-total earnings assets- cash and due from banks), Fixed assets, Other earning assets, Insurance assets, investments in property and equity investments in associates.

Table 4
Results of the estimating equation system (1)

The capital ratios are those defined in the Basel III regulatory framework and the equity to total assets ratios. Results of the estimating equation system (1). The capital ratios are those defined in the Basel III regulatory framework and the equity to total assets ratios. The liquidity ratios are the NSFR defined in the Basel III document of December 2010 (NSFR 2010) and the NSFR defined in the Basel III document of October 2014 (NSFR 2014). See table (2) for the definition of the explanatory variables. In both the equations all bank-level explanatory variables are replaced with their one-quarter lagged value. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

	Basel III Leverage (1a)	Basel III Leverage (1b)	Equity to Total assets (2a)	Equity to Total Assets (2b)
Capital Equation				
NSFR_14	0.018**		0.06*	
	(3.21)		(1.87)	
NSFR_10		0.019**		0.06*
		(3.27)		(1.77)
Roe	0.08***	0.08***	0.09***	0.09***
	(4.20)	(4.20)	(4.46)	(4.45)
LLP to TA	-0.0002***	-0.0002***	-0.0002***	-0.0002***
	(-3.65)	(-3.64)	(-3.30)	(-3.29)
MKT_BV	0.005	0.005	0.023**	0.023**
	(0.90)	(0.86)	(2.89)	(2.83)
Size	-0.014***	-0.014***	-0.014***	-0.014***
	(-13.10)	(-13.11)	(-11.08)	(-11.11)
GDP Growth	0.150***	0.150***	0.187***	0.186***
	(3.68)	(3.70)	(3.74)	(3.74)
CDS spreads	0.049***	0.049***	0.056***	0.056***
	(14.34)	(14.46)	(13.28)	(13.37)
Liquidity Equation				
Capital	2.868***	2.746***	0.922**	0.909**
	(6.19)	(6.09)	(2.15)	(2.20)
Size	0.084**	0.084**	0.059***	0.061***
	(6.86)	(7.02)	(4.68)	(4.88)
Interbank Spread	10.861***	10.544***	14.86***	14.358***
	(3.45)	(3.44)	(4.32)	(4.29)
ECB Lending	0.081**	0.078**	0.116***	0.111***
	(2.58)	(2.55)	(3.30)	(3.24)
GDP Growth	0.622**	0.596**	0.60*	0.581*
	(2.00)	(1.96)	(1.78)	(1.74)
CDS spreads	0.14***	0.134***	0.21***	0.202***
	(4.02)	(3.97)	(6.10)	(6.00)

Table 5
Results of the estimated equation system (1) using Basel II risk weighted capital ratios and the market capital ratio

Results of the estimating equation system (1). The capital ratios are those defined in the Basel II regulatory framework and the ratio of the market value of equity over the total market value. The liquidity ratios are the NSFR defined in the Basel III document of December 2010 (NSFR 2010) and the NSFR defined in the Basel III document of October 2014 (NSFR 2014). See table (2) for the definition of the explanatory variables. In both the equations all bank-level explanatory variables are replaced with their one-quarter lagged value. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

	CET 1	CET 1	Total Capital	Total Capital	Market Capital	Market Capital
	(3a)	(3b)	(4a)	(4b)	(5a)	(5b)
Capital Equation						
NSFR_14	0.034***		0.129*		-0.094***	
	(3.41)		(1.86)		(-5.18)	
NSFR_10		0.034***		0.136*		-0.092***
		(3.54)		(1.91)		(5.02)
Roe	0.03	0.02	-0.034**	-0.034**	0.235***	0.233***
	(0.25)	(0.28)	(-2.20)	(-2.20)	(3.75)	(3.72)
LLP to TA	-0.0003***	-0.0003***	-0.0002***	-0.0002***	-0.0005**	-0.0005**
	(-3.01)	(-3.03)	(-2.42)	(-2.43)	(-2.74)	(-2.76)
MKT_BV	-0.026**	-0.027**	0.005	0.005	0.10***	0.10***
	(-3.16)	(3.28)	(0.57)	(0.59)	(5.92)	(5.85)
Size	0.023***	0.026***	0.027***	0.026***	-0.048***	-0.048***
	(10.47)	(10.43)	(20.12)	(20.13)	(-5.92)	(-1.49)
GDP Growth	-0.147**	-0.146**	-0.10**	-0.101**	0.583**	0.578**
	(-2.15)	(-2.15)	(-2.18)	(-2.17)	(2.95)	(2.93)
CDS Spreads	-0.018**	-0.018**	-0.010**	-0.010**	0.048***	0.047***
	(-2.46)	(-2.44)	(-2.11)	(-2.10)	(5.46)	(5.41)
Liquidity Equation						
Capital	0.156	0.163	0.114	0.129	0.242***	0.243***
	(1.24)	(1.43)	(0.55)	(0.59)	(3.43)	(3.53)
Size	0.043***	0.043***	0.043***	0.044***	0.051***	0.051***
	(3.14)	(3.32)	(2.90)	(3.03)	(3.79)	(3.96)
Interbank Spread	17.018***	16.441***	17.95***	17.40***	15.138***	14.578***
	(5.24)	(5.18)	(5.20)	(5.17)	(4.41)	(4.37)
ECB Lending	0.154***	0.147***	0.145***	0.143***	0.117***	0.112***
	(3.98)	(3.91)	(3.85)	(3.80)	(3.08)	(3.02)
GDP Growth	0.475*	0.452*	0.438	0.419	0.556	0.539
	(1.65)	(1.55)	(1.15)	(1.13)	(1.51)	(1.49)
CDS spreads	0.223***	0.214***	0.237***	0.228***	0.250***	0.241***
	(7.13)	(7.02)	(7.28)	(7.18)	(7.22)	(7.14)

Table 6
Results of the Baseline model of CDS spread changes

Regression of quarterly CDS spread over capital, liquidity, bank specific and structural variables. This table examines the association between CDS spreads and capital and funding liquidity risk using alternatively all the capital formulations and both versions of the NSFR. See table (2) and (3) for the definition of the explanatory variables. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital										
Basel III	3.99**	3.972**								
leverage	(2.05)	(2.04)								
Equity/			4.024*	4.003*						
TA			(1.94)	(1.93)						
CET1					0.589	0.587				
					(1.57)	(1.57)				
Total							2.491**	2.482**		
Capital							(3.36)	(3.34)		
Market									-3.892*	-3.885*
Capital									(-1.92)	(-1.91)
Liquidity										
NSFR 2010	0.139		0.179		0.208		0.171		0.238	
	(0.64)		(0.81)		(0.98)		(0.87)		(1.37)	
NSFR 2014		0.151		0.187		0.216		0.179		0.240
		(0.72)		(0.87)		(1.05)		(0.94)		(1.41)
Asset Quality										
NPL/TL	2.047***	2.051***	1.895**	1.899**	1.980**	1.983**	1.840**	1.844**	1.810**	1.811***
	(3.92)	(3.95)	(3.67)	(3.69)	(3.76)	(3.78)	(3.19)	(3.21)	(4.18)	(4.19)
Performance										
ROA	-0.218	-0.215	-0.480**	-0.479**	-0.286***	-0.285***	-0.314***	-0.314***	-0.294***	-0.294***
	(-1.55)	(-1.54)	(-3.20)	(-3.20)	(-4.35)	(-4.34)	(-4.35)	(-4.35)	(-6.19)	(-6.19)
Business models										
Int. income	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.003***	0.003***
to tot. income	(7.44)	(7.42)	(7.88)	(7.87)	(6.83)	(6.82)	(6.63)	(6.63)	(6.01)	(6.00)
Loans/	1.680**	1.678**	1.641**	1.639**	1.887**	1.884**	1.774**	1.771**	1.841**	1.839**
TA	(2.66)	(2.65)	(2.63)	(2.62)	(2.82)	(2.82)	(3.36)	(3.35)	(3.40)	(3.39)
Size	1.415**	1.417**	1.494***	1.495***	1.502**	1.503**	1.468***	1.469***	1.305***	1.306***
	(3.68)	(3.67)	(4.04)	(4.04)	(3.61)	(3.61)	(4.12)	(4.11)	(3.06)	(3.06)
Structural variables and market wide factors										
Equity	0.004**	0.004**	0.004**	0.004**	0.003**	0.003**	0.004**	0.004**	0.003*	0.003*
volatility	(3.13)	(3.14)	(3.29)	(3.30)	(2.94)	(2.96)	(3.41)	(3.42)	(2.00)	(2.01)
Euro	-1.258**	-1.261**	-1.241**	-1.244**	-1.291**	-1.295**	-1.445***	-1.447***	-0.661*	-0.665*
Stoxx	(-3.66)	(-3.68)	(-3.58)	(-3.60)	(-3.69)	(-3.71)	(-4.06)	(-4.08)	(-1.75)	(-1.77)
Term	0.070***	0.070***	0.070***	0.070***	0.066***	0.066***	0.064***	0.064***	0.056***	0.056***
Spread	(7.42)	(7.43)	(7.41)	(7.42)	(6.31)	(6.32)	(6.02)	(6.03)	(4.12)	(4.13)
Constant	-4.652*	-4.668*	-5.195**	-5.206**	-5.061*	-5.070*	-4.699*	-4.711*	-5.051*	-5.054*
	(-1.83)	(-1.83)	(-2.06)	(-2.06)	(-1.81)	(-1.81)	(-1.87)	(-1.87)	(-1.84)	(-1.84)
Obs.	841									
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level
R^2	63.56%	63.57%	63.47%	63.50%	61.33%	61.36%	63.91%	63.93%	68.33%	68.35%

Table 7
Results of the Baseline model with threshold effects

Regression of quarterly CDS spread over capital, liquidity, bank specific and structural variables. This table examines the thresholds effects of liquidity risk using alternatively all the capital formulations and both versions of the NSFR. See table (2) and (3) for the definition of the explanatory variables. NSFR 10 < 1 and NSFR 14 <1 are dummy variables which take value one when respectively the first and the last version of the NSFR takes a value below one. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital										
Basel III	3.93**	4.086**								
leverage	(2.10)	(2.17)								
Equity/			3.974*	4.099*						
TA			(2.02)	(2.08)						
CET1					0.588	0.592				
					(1.60)	(1.60)				
Total							2.522**	2.503**		
Capital							(3.35)	(3.31)		
Market									-3.873*	-3.840*
Capital									(-1.90)	(-1.88)
Liquidity										
NSFR 2010	0.286		0.329*		0.363*		0.342*		0.301*	
	(1.54)		(1.68)		(1.92)		(1.88)		(1.68)	
NSFR 2014		0.327*		0.185*		0.402**		0.353*		0.315*
		(1.72)		(1.85)		(2.13)		(1.99)		(1.81)
NSFR 10 <1	0.089*		0.092*		0.977*		0.107*		0.041	
	(1.71)		(1.80)		(1.67)		(2.09)		(0.63)	
NSFR 14 <1		0.129**		0.127**		0.137**		0.127**		0.057
		(3.20)		(3.15)		(3.22)		(3.17)		(1.00)
Asset Quality										
NPL/TL	2.056***	2.026***	1.899**	1.869**	1.980**	1.957**	1.837**	1.817**	1.813**	1.804***
	(3.92)	(3.90)	(3.64)	(3.62)	(3.75)	(3.73)	(3.17)	(3.16)	(4.14)	(4.13)
Performance										
ROA	-0.198	-0.191	-0.471**	-0.472**	-0.278***	-0.273***	-0.313***	-0.309***	-0.291***	-0.288***
	(-1.51)	(-1.51)	(-3.32)	(-3.34)	(-4.31)	(-4.31)	(-4.49)	(-4.54)	(-6.10)	(-6.04)
Business models										
Int. income	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.003***	0.004***
to tot. income	(7.81)	(8.25)	(8.27)	(8.70)	(7.12)	(7.44)	(6.99)	(7.20)	(6.03)	(5.95)
Loans/	1.421**	1.663**	1.643**	1.628**	1.898**	1.887**	1.777**	1.767**	1.834**	1.828**
TA	(3.77)	(2.66)	(2.66)	(2.64)	(2.88)	(2.87)	(3.42)	(3.40)	(3.35)	(3.34)
Size	1.415**	1.422**	1.498***	1.501***	1.501**	1.514**	1.470***	1.477***	1.305**	1.308**
	(3.68)	(3.80)	(4.13)	(4.17)	(3.70)	(2.87)	(4.23)	(4.25)	(3.07)	(3.08)
Structural variables and market wide factors										
Equity	0.004**	0.004**	0.004**	0.004**	0.003**	0.003**	0.004**	0.004**	0.003*	0.003*
volatility	(3.15)	(3.19)	(3.31)	(3.35)	(2.94)	(2.95)	(3.42)	(3.43)	(2.00)	(2.02)
Euro	-1.283**	-1.261**	-1.269**	-1.278**	-1.319**	-1.328**	-1.447***	-1.48***	-0.677*	-0.687*
Stoxx	(-3.70)	(-3.72)	(-3.60)	(-3.62)	(-3.75)	(-3.77)	(-4.13)	(-4.13)	(-1.80)	(-1.82)
Term	0.069***	0.070***	0.070***	0.070***	0.066***	0.065***	0.063***	0.063***	0.056***	0.056***
Spread	(7.11)	(7.01)	(7.09)	(6.98)	(6.00)	(5.86)	(5.70)	(5.63)	(4.08)	(4.06)
Constant	-4.792*	-4.827*	-5.328**	-5.369**	-5.224*	-5.282*	-4.845*	-4.889*	-5.086*	-5.105*
	(-1.92)	(-1.94)	(-2.15)	(-2.18)	(-1.91)	(-1.93)	(-1.98)	(-1.99)	(-1.87)	(-1.87)
Obs.	841									
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level
R^2	63.79%	64.05%	63.72%	63.96%	61.62%	61.90%	64.24%	64.93%	68.37%	68.42%

Table 8
Results of the Baseline model with indirect effects of liquidity risk on CDS spread changes

Regression of quarterly CDS spread over capital, liquidity, bank specific and structural variables. This table examines the indirect effects of liquidity risk using alternatively all the capital formulations and both versions of the NSFR. See table (2) and (3) for the definition of the explanatory variables. Cap*NSFR 10 and Cap*NSFR 14 are the product of the capital formulation and the dummy variables NSFR 10 < 1 and NSFR 14 < 1 respectively. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital										
Basel III	3.66*	3.605*								
leverage	(1.99)	(1.94)								
Equity/			4.377*	4.196*						
TA			(2.08)	(2.02)						
CET1					0.560	0.558				
					(1.64)	(1.65)				
Total							2.269**	2.251**		
Capital							(2.95)	(2.93)		
Market									-3.927*	-3.893*
Capital									(-1.94)	(-1.92)
Liquidity										
NSFR 2010	0.227		0.658		0.378*		0.376*		0.260	
	(1.14)		(0.30)		(2.05)		(2.08)		(1.44)	
NSFR 2014		0.276		0.119		0.408**		0.372*		0.261
		(1.37)		(0.57)		(2.21)		(2.09)		(1.46)
Cap*NSFR	1.379*		-0.79		1.087**		0.890**		0.167**	
10	(1.66)		(-1.21)		(2.10)		(2.08)		(2.46)	
Cap*NSFR		2.513**		-0.536		1.473**		0.966***		0.184**
14		(3.51)		(-0.76)		(3.58)		(4.01)		(2.86)
Asset Quality										
NPL/TL	2.079***	2.068***	2.053 **	2.016***	1.961**	1.927**	1.852**	1.834**	1.813**	1.813***
	(3.95)	(3.97)	(3.98)	(3.93)	(3.69)	(3.64)	(3.20)	(3.18)	(4.22)	(4.22)
Performance										
ROA	-0.199	-0.185	-0.497**	-0.489**	-	-	-	-	-0.30***	-0.30***
	(-1.48)	(-1.43)	(-3.40)	(-3.36)	0.295***	0.298***	0.326***	0.324***	(-6.18)	(-6.18)
					(-4.47)	(-4.58)	(-4.65)	(-4.71)		
Business models										
Int. income	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.003***	0.004***
to tot. income	(7.53)	(7.80)	(7.95)	(7.89)	(6.74)	(6.88)	(7.16)	(7.37)	(5.98)	(6.00)
Loans/	1.689**	1.683**	1.604**	1.617**	1.925**	1.921**	1.775**	1.758**	1.855**	1.857**
TA	(2.71)	(2.72)	(2.56)	(2.58)	(3.01)	(3.03)	(3.51)	(3.47)	(3.42)	(3.41)
Size	1.435**	1.450**	1.472***	1.480***	1.512**	1.518**	1.481***	1.486***	1.307**	1.311**
	(3.78)	(3.82)	(3.99)	(4.00)	(3.82)	(3.88)	(4.35)	(4.35)	(3.05)	(3.05)
Structural variables and market wide factors										
Equity	0.004**	0.004**	0.004**	0.004**	0.003**	0.003**	0.004**	0.004**	0.003*	0.003*
volatility	(3.15)	(3.18)	(3.31)	(3.38)	(3.05)	(3.10)	(3.44)	(3.45)	(2.00)	(2.01)
Euro	-1.278**	-1.297**	-1.267**	-1.262**	-1.319**	-1.337**	-1.48***	-1.46***	-0.653*	-0.67*
Stoxx	(-3.72)	(-3.75)	(-3.85)	(-3.83)	(-3.79)	(-3.80)	(-4.35)	(-4.08)	(-1.74)	(-1.77)
Term	0.069***	0.070***	0.070***	0.070***	0.066***	0.066***	0.063***	0.063***	0.056***	0.056***
Spread	(7.24)	(7.12)	(7.74)	(7.63)	(6.23)	(6.20)	(5.80)	(5.77)	(4.13)	(4.13)
Constant	-4.807*	-4.911*	-4.879**	-4.997**	-5.239*	-5.313*	-4.938*	-4.967*	-5.118*	-5.136*
	(-1.92)	(-1.96)	(-1.97)	(-2.02)	(-1.97)	(-2.02)	(-2.05)	(-2.06)	(-1.85)	(-1.85)
Obs.	841									
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level
R^2	63.69%	63.97%	63.62%	63.56%	61.84%	62.21%	64.44%	64.57%	68.38%	68.40%

Table 9
Replacing LLP to TA with LLR to NPL in the capital equation

This table shows the results of estimating system (1) using GMM with an alternative measure of credit risk in the capital equation. See table (2) for the definition of the explanatory variables. In both the equations all bank-level explanatory variables are replaced with their one-quarter lagged value. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

PANEL A	Basel III Leverage (1a)	Basel III Leverage (1b)	Equity to Total assets (2a)	Equity to Total Assets (2b)
Capital Equation				
NSFR_14	0.032***		0.018**	
	(6.19)		(2.59)	
NSFR_10		0.033***		0.018**
		(6.17)		(2.68)
Control Variables	YES	YES	YES	YES
Liquidity Equation				
Capital	3.359***	3.252***	2.051***	2.060**
	(7.30)	(7.27)	(4.76)	(4.80)
Control Variables	YES	YES	YES	YES

PANEL B	CET 1 (3a)	CET 1 (3b)	Total Capital (4a)	Total Capital (4b)	Market Capital (5a)	Market Capital (5b)
Capital Equation						
NSFR_14	0.045***		0.023***		-0.092***	
	(4.20)		(3.08)		(3.88)	
NSFR_10		0.048***		0.025**		-0.088***
		(4.36)		(3.19)		(3.75)
Control Variables	YES	YES	YES	YES	YES	YES
Liquidity Equation						
Capital	0.272*	0.277*	0.579***	0.586***	0.202***	0.203***
	(1.65)	(1.67)	(2.60)	(2.68)	(2.97)	(3.06)
Control Variables	YES	YES	YES	YES	YES	YES

Table 10
Replacing the NSFR with alternative liquidity proxies

This table shows the results of estimating system (1) using GMM two alternative measures of liquidity risk in both equations. Liquidity creation is the "cat-fat" measure of liquidity creation as defined in Berger and Bouwman (2009). The LT GAP is the "liquidity transformation gap" (LT gap) of Deep and Schaefer (2004). The LT gap is the difference between liquid liabilities and liquid assets held by a bank divided by its total assets. See table (2) and (4) for the definition of the explanatory variables. In both the equations all bank-level explanatory variables are replaced with their one-quarter lagged value. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

PANEL A

	Basel III Leverage (1a)	Basel III Leverage (1b)	Equity to Total assets (2a)	Equity to Total Assets (2b)
Capital Equation				
Liquidity Creation	-0.015* (1.75)		-0.028* (-1.79)	
LT GAP		-0.013* (1.80)		-0.05*** (-4.54)
Control Variables	YES	YES	YES	YES
Liquidity Equation				
Capital	-0.69** (-2.01)	-1.17** (-2.71)	-0.959* (3.62)	-0.43 (-1.11)
Control Variables	YES	YES	YES	YES

PANEL B

	CET 1 (3a)	CET 1 (3b)	Total Capital (4a)	Total Capital (4b)	Market Capital (5a)	Market Capital (5b)
Capital Equation						
Liquidity Creation	-0.064** (-2.91)		-0.017 (-1.01)		0.572* (1.55)	
LT GAP		-0.021** (1.87)		-0.028*** (-3.59)		0.134*** (5.32)
Control Variables	YES	YES	YES	YES	YES	YES
Liquidity Equation						
Capital	-0.93 (-1.26)	-0.01 (-1.09)	0.856** (2.29)	-1.15*** (-5.78)	0.407*** (8.73)	0.222*** (4.23)
Control Variables	YES	YES	YES	YES	YES	YES

Table 11
Considering income diversification in the liquidity equation

This table shows the results of estimating system (1) using GMM and considering income diversification in the liquidity equation. Income diversification is the ratio of interest income over total income. See table (2) and (4) for the definition of the explanatory variables. In both the equations all bank-level explanatory variables are replaced with their one-quarter lagged value. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

PANEL A						
	Basel III Leverage (1a)	Basel III Leverage (1b)	Equity to Total assets (2a)	Equity to Total Assets (2b)		
Capital Equation						
NSFR_14	0.023***		0.03*			
	(4.12)		(1.65)			
NSFR_10		0.024***		0.07*		
		(4.25)		(1.60)		
Control Variables	YES	YES	YES	YES		
Liquidity Equation						
Capital	3.204***	3.085***	1.213**	1.28**		
	(6.67)	(6.60)	(2.09)	(2.21)		
Control Variables	YES	YES	YES	YES		
PANEL B						
	CET 1 (3a)	CET 1 (3b)	Total Capital (4a)	Total Capital (4b)	Market Capital (5a)	Market Capital (5b)
Capital Equation						
NSFR_14	0.037***		0.012*		-0.088***	
	(3.44)		(1.74)		(-4.88)	
NSFR_10		0.039***		0.013*		-0.085***
		(3.57)		(1.81)		(-4.68)
Control Variables	YES	YES	YES	YES	YES	YES
Liquidity Equation						
Capital	0.147	0.155	-0.007	0.159	0.247***	0.250**
	(1.17)	(1.24)	(-0.30)	(0.70)	(3.43)	(3.55)
Control Variables	YES	YES	YES	YES	YES	YES

Table 12
Liquidity risk management during the crisis

This table test the liquidity management assumptions during the crisis. The dependent variables are NSFR 2010 and NSFR 2014, respectively. NPL/TL_{t-1} is the ratio of non-performing loans over total loans of the previous quarter. We use this variable to examine the connections between funding liquidity risk and credit risk of the loan portfolio. We include the variation of loans over total loans, the ratio of deposits over total funding, the Basel III leverage ratio and the logarithm of total assets (size). All the mentioned variables are interacted with the interbank spread as defined in table (2) to take in consideration the effect of the crisis. We control for bank fixed effects and time fixed effects using quarterly dummies. Standard errors are clustered at the bank-level. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

	NSFR 2010	NSFR 2014
NPL/TL_{t-1}	-0.431**	-0.443**
	(-2.63)	(-2.67)
ΔLoans	0.194**	0.195**
	(2.70)	(2.66)
ΔLoans*Interbank spread	32.078*	32.317**
	(1.76)	(1.76)
Deposit/Total $Funding_{t-1}$	0.149	0.190
	(1.05)	(1.32)
Deposit/Total $Funding_{t-1}$*Interbank spread	17.834	18.550
	(1.66)	(1.69)
Basel III $leverage_{t-1}$	0.593	0.575
	(0.45)	(0.72)
Basel III $leverage_{t-1}$*Interbank spread	-27.548**	-27.832**
	(-2.57)	(-2.57)
$Size_{t-1}$	-0.033	-0.032
	(-0.26)	(-0.26)
Size*Interbank $spread_{t-1}$	-5.757**	-5.751**
	(-2.21)	(-2.19)
Observations	954	954
Quarterly Dummies	YES	YES
Bank fixed effects	YES	YES
Cluster	Bank-level	Bank-level
R^2 adjusted	0.173	0.183

Table 13
Baseline model with alternative proxies of Asset quality and Performance

Regression of quarterly CDS spread over capital, liquidity, bank specific and structural variables. This table display the results of the regression model of table 6 using alternative balance sheet ratios. See table (2) and (3) for the definition of the explanatory variables. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital										
Basel III leverage	6.56**	6.546**								
	(2.90)	(2.89)								
Equity/TA			6.102**	6.085**						
			(2.66)	(2.65)						
CET1					0.923	0.923				
					(1.43)	(1.43)				
Total Capital							4.093***	4.095***		
							(5.05)	(5.03)		
Market Capital									-4.482**	-4.480**
									(-2.24)	(-2.23)
Liquidity										
NSFR 2010	-0.202		-0.229		-0.168		-0.107		-0.010	
	(-1.14)		(-1.32)		(-0.87)		(-0.81)		(-0.07)	
NSFR 2014		-0.179		-0.206		-0.146		-0.089		0.002
		(-1.04)		(-1.23)		(-0.78)		(-0.71)		(0.10)
Asset Quality										
LLP/TA	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(-4.88)	(-4.87)	(-6.08)	(-6.07)	(-5.04)	(-5.04)	(-6.87)	(-6.87)	(-5.61)	(-5.61)
Performance										
ROE	-0.442**	-0.443**	-0.511**	-0.511**	-0.486**	-0.486**	-0.359**	-0.359**	-0.258**	-0.251**
	(-2.40)	(-2.40)	(-3.03)	(-3.02)	(-2.58)	(-2.57)	(-2.59)	(-2.58)	(-2.14)	(-2.14)
Business models										
Int. income to tot. income	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.003***	0.003***
	(6.45)	(6.46)	(6.92)	(6.93)	(5.45)	(5.47)	(5.17)	(5.18)	(4.63)	(4.63)
Loans/TA	2.155**	2.153**	2.084**	2.082**	2.078**	2.087**	2.197***	2.195***	2.182***	2.180***
	(3.64)	(3.63)	(3.48)	(3.48)	(3.10)	(3.10)	(5.01)	(5.01)	(4.04)	(4.04)
Size	1.706***	1.709***	1.843***	1.846***	1.816***	1.819***	1.720***	1.722***	1.579**	1.580**
	(5.10)	(5.11)	(5.79)	(5.80)	(4.86)	(4.87)	(5.72)	(5.74)	(3.90)	(3.91)
Structural variables and market wide factors										
Equity volatility	0.004**	0.004**	0.004**	0.004**	0.003**	0.003**	0.004**	0.004**	0.003**	0.003**
	(3.72)	(3.72)	(3.73)	(3.72)	(3.09)	(3.09)	(4.08)	(4.08)	(2.52)	(2.54)
Euro Stoxx	-0.899**	-0.897**	-0.975**	-0.973**	-1.072**	-1.071**	-1.378***	-1.378***	-0.198	-0.198
	(-2.52)	(-2.52)	(-2.70)	(-2.69)	(-3.28)	(-3.27)	(-4.44)	(-4.43)	(-0.57)	(-0.57)
Term Spread	0.072***	0.072***	0.070***	0.071***	0.064***	0.064***	0.059***	0.059***	0.054***	0.054***
	(6.40)	(6.41)	(6.54)	(6.55)	(4.98)	(5.00)	(4.96)	(4.97)	(3.50)	(3.51)
Constant	-7.056**	-7.095**	-7.596**	-7.636**	-6.966**	-7.006*	-6.307**	-6.332**	-7.458**	-7.481**
	(-3.17)	(-3.19)	(-3.49)	(-3.51)	(-2.81)	(-2.83)	(-3.03)	(-3.05)	(-2.95)	(-2.96)
Observations	977	977	997	997	894	894	942	942	925	925
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level
R^2	62.75%	62.71%	62.49%	62.45%	57.98%	57.95%	65.10%	65.08%	66.58%	66.57%

Table 14
Model with threshold effects and alternative proxies of Asset quality and Performance

Regression of quarterly CDS spread over capital, liquidity, bank specific and structural variables. This table display the results of the regression model of table 7 using alternative balance sheet ratios. See table (2) and (3) for the definition of the explanatory variables. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital										
Basel III	6.508**	6.605**								
leverage	(2.94)	(2.94)								
Equity/			6.039**	6.090**						
TA			(2.70)	(2.71)						
CET1					0.922	0.927				
					(1.44)	(1.44)				
Total							4.096***	4.079***		
Capital							(5.06)	(4.99)		
Market									-4.474**	-4.445**
Capital									(-2.21)	(-2.19)
Liquidity										
NSFR 2010	-0.703		-0.083		0.008		0.064		0.110	
	(-0.47)		(-0.55)		(0.04)		(0.47)		(0.66)	
NSFR 2014		-0.008		-0.032		0.069		0.090		0.131
		(-0.06)		(-0.21)		(0.39)		(0.72)		(0.88)
NSFR 10 <1	0.083		0.091		0.110		0.107		0.078	
	(1.34)		(1.57)		(1.39)		(1.63)		(0.88)	
NSFR 14 <1		0.124**		0.124**		0.152**		0.128**		0.095
		(2.80)		(3.10)		(2.41)		(2.35)		(1.25)
Asset Quality										
LLP/TA	-	-	-	-	-	-	-	-	-	-
	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(-4.88)	(-4.33)	(-6.07)	(-5.88)	(-5.51)	(-5.32)	(-7.59)	(-7.34)	(-6.00)	(-5.94)
Performance										
ROE	-0.434**	-0.428**	-0.504**	-0.502**	-0.478**	-0.472**	-0.353**	-0.351**	-0.247**	-0.245**
	(-2.38)	(-2.37)	(-3.02)	(-3.03)	(-2.62)	(-2.64)	(-2.62)	(-2.63)	(-2.12)	(-2.11)
Business models										
Int. income	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***	0.003***	0.003***
to tot. income	(6.47)	(6.88)	(6.95)	(7.43)	(5.46)	(5.77)	(5.29)	(5.45)	(4.46)	(4.50)
Loans/	2.130**	2.111**	2.058**	2.042**	2.057**	2.034**	2.164***	2.147***	2.145**	2.138***
TA	(3.58)	(3.58)	(3.45)	(3.45)	(3.01)	(2.97)	(4.91)	(4.86)	(3.78)	(3.82)
Size	2.130***	1.698***	1.834***	1.834***	1.806***	1.805***	1.707***	1.711***	1.566**	1.569**
	(3.58)	(5.17)	(5.83)	(5.87)	(3.01)	(4.88)	(5.72)	(5.75)	(3.81)	(3.83)
Structural variables and market wide factors										
Equity	0.004**	0.004**	0.004**	0.004**	0.003**	0.003**	0.004**	0.004**	0.003**	0.003**
volatility	(3.47)	(3.85)	(3.79)	(3.81)	(3.17)	(3.18)	(4.24)	(4.25)	(2.55)	(2.57)
Euro	-0.917**	-0.925**	-0.995**	-1.002**	-1.099**	-1.073**	-1.40***	-	-0.219	-0.225
Stoxx	(-2.54)	(-2.56)	(-2.70)	(-2.73)	(-3.32)	(-3.36)	(-4.48)	1.403***	(-0.64)	(-0.66)
								(-4.50)		
Term	0.072***	0.072***	0.070***	0.071***	0.063***	0.063***	0.058***	0.059***	0.053***	0.053***
Spread	(6.17)	(6.10)	(6.25)	(6.19)	(4.77)	(4.70)	(4.72)	(4.69)	(3.40)	(3.38)
Constant	-7.126**	-7.160**	-7.654**	-7.692**	-7.039**	-7.073**	-6.365**	-6.404**	-7.463**	-7.488**
	(-3.27)	(-3.29)	(-3.59)	(-3.62)	(-2.91)	(-2.93)	(-3.14)	(-3.15)	(-2.94)	(-2.95)
Observations	977	977	997	997	894	894	942	942	925	925
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level
R^2	62.93%	63.10%	62.49%	62.84%	58.34%	58.60%	65.39%	65.50%	66.72%	66.77%

Table 15
Results of the Baseline model with indirect effects of liquidity risk on CDS spread changes and alternative measures of Asset Quality and Performance

Regression of quarterly CDS spread over capital, liquidity, bank specific and structural variables. This table display the results of the regression model of table 8 using alternative balance sheet ratios. See table (2) and (3) for the definition of the explanatory variables. * indicate statistical significance at 10% level, ** indicate statistical significance at 5% level, *** indicate statistical significance at 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capital										
Basel III	6.394***	6.187**								
leverage	(3.01)	(2.81)								
Equity/			5.582**	5.454**						
TA			(2.29)	(2.22)						
CET1					0.869	0.867				
					(1.46)	(1.47)				
Total							3.859***	3.842***		
Capital							(4.89)	(4.78)		
Market									-4.573*	-4.542**
Capital									(-2.22)	(-2.22)
Liquidity										
NSFR 2010	-0.162		-0.116		0.068		0.077		0.164	
	(-0.98)		-(0.55)		(0.39)		(0.62)		(0.11)	
NSFR 2014		-0.088		-0.072		0.118		0.092		0.027
		-(0.53)		(-0.36)		(0.69)		(0.77)		(0.18)
Cap*NSFR	0.642		0.788**		1.562**		0.832**		0.239	
10	(0.54)		(2.34)		(2.20)		(2.21)		(1.44)	
Cap*NSFR		1.769*		1.037**		2.012**		0.92**		0.256
14		(1.79)		(3.04)		(3.47)		(3.05)		(1.64)
Asset Quality										
LLP/TA	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(-4.85)	(-4.76)	(-5.88)	(-5.84)	(-5.42)	(-5.39)	(-7.72)	(-7.44)	(-5.55)	(-5.54)
Performance										
ROE	-0.441**	-0.438**	-0.526**	-0.530**	-0.487**	-0.488**	-0.356**	-0.356**	-0.248**	-0.229**
	(-2.40)	(-2.40)	(-3.12)	(-3.13)	(-2.69)	(-2.75)	(-2.64)	(-2.65)	(-2.13)	(-2.13)
Business models										
Int. income	0.004***	0.004***	0.003***	0.003***	0.003***	0.003***	0.004***	0.004***	0.003***	0.004***
to tot. income	(6.54)	(6.59)	(6.90)	(6.93)	(5.71)	(5.75)	(5.48)	(5.49)	(4.59)	(4.62)
Loans/	2.158**	2.159**	2.114**	2.119**	1.799**	2.064**	2.172***	2.155***	2.195***	2.198***
TA	(3.68)	(3.70)	(3.59)	(3.59)	(3.20)	(3.18)	(5.06)	(5.01)	(4.05)	(4.05)
Size	1.716***	1.735***	1.840***	1.842***	1.799***	1.796***	1.717***	1.722***	1.580**	1.585**
	(5.25)	(5.28)	(5.80)	(5.81)	(5.07)	(5.11)	(5.89)	(5.90)	(3.88)	(3.90)
Structural variables and market wide factors										
Equity	0.004**	0.004**	0.004**	0.004**	0.003**	0.003**	0.004**	0.004***	0.003**	0.003**
volatility	(3.77)	(3.79)	(3.77)	(3.78)	(3.30)	(3.34)	(4.23)	(4.24)	(2.52)	(2.53)
Euro	-0.906**	-0.917**	-0.972**	-0.972**	-1.124**	-1.121**	-	-	-0.182	-0.184
Stoxx	(-2.53)	(-2.56)	(-2.68)	(-2.68)	(-3.40)	(-3.42)	1.386***	1.385***	(-0.52)	(-0.53)
							(-4.45)	(-4.44)		
Term	0.072***	0.072***	0.070***	0.070***	0.064***	0.064***	0.059***	0.059***	0.053**	0.054**
Spread	(6.31)	(6.18)	(6.36)	(6.36)	(4.94)	(4.95)	(4.77)	(4.76)	(3.48)	(3.49)
Constant	-7.137**	-7.291*	-7.705**	-7.764**	-7.031**	-7.070**	-6.450**	-6.485**	-7.538**	-7.580**
	(-3.30)	(-3.35)	(-3.57)	(-3.57)	(-3.02)	(-3.07)	(-3.25)	(-3.26)	(-2.94)	(-2.96)
Obs.	977	977	997	997	894	894	942	942	925	925
Bank fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level	Bank-level
R^2	62.77%	62.89%	62.64%	62.72%	58.97%	59.43%	65.50%	65.58%	66.67%	66.67%

Bank Credit Ratings, Capital Structure Adjustments and Lending

Claudia Girardone

Essex Business School
University of Essex
Wivenhoe Park – Colchester, CO4 3SQ, UK
cgirard@essex.ac.uk

Alex Sclip[13]

Department of Economics and Statistics
University of Udine
Via Tomadini 30A – 33100 Udine, Italy
sclip.alex@spes.uniud.it

Abstract

This paper empirically examines the causal effect of bank credit rating changes on bank capital structure decisions. Banks adjust their capital structure following a credit rating downgrade. Adjustments involve: leverage, rating sensitive liabilities and lending. Rating upgrades do not affect capital structure activities suggesting that banks target minimum rating levels. In our study, we also exploit the asymmetric impact of downgrades of banks based in Greece, Ireland, Italy, Spain and Portugal during the EU sovereign debt crisis. This asymmetric effect leads to greater capital adjustments, reductions in long-term funding and lending of banks from those countries relative to other banks. Our results are consistent with the expectation of discrete cost (benefits) associated with rating changes.

Keywords: Bank ratings; Bank capital structure; Lending; Placebo effects; EU sovereign debt crisis.

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1. Introduction

Theoretical (Diamond and Rajan, 2000; Allen et al., 2011; De Angelo and Stulz, 2015) and empirical research (Brewer et al., 2008; Flannery and Rangan, 2008; Gropp and Heider, 2010) have shown the existence and the determinants of banks' optimal capital ratios. However, shocks may create a wedge between optimal and actual capital ratios. In this context, the literature has investigated the effect of excess control rights (Lepetit et al., 2015) and the international factors (De Jonghe and Öztekin, 2015) affecting bank capital adjustments. In this paper, we consider an important aspect of bank capital structure management, i.e. the capital structure adjustment process following a rating change. In particular, we examine the influence of credit ratings changes on capital, funding and lending decisions in a partial adjustment framework.

The impact of credit ratings on bank capital structure decisions has not been formally investigated in the banking literature to date. Credit ratings assigned by the major rating agencies, such as Standard and Poor's (S&P), Moody's and Fitch are widely used by investors and regulators as objective measures of the quality of financial instruments. These ratings directly affect banks in various ways. On the liability side, ratings directly drive the issuance and the cost of long-term debt and are also used in interbank markets to determine the eligibility of counterparties to participate in a transaction. The impaired access to external funding has the direct consequence of reducing lending supply (Adelino and Ferreira, 2016). Moreover, rating changes also affect the cost of equity issuance, since downgrades have a direct negative impact on bank share prices (Caselli et al., 2016; Correa et al., 2014). More informally the anecdotal evidence in the financial press supports the impact of bank rating downgrades on lending, access to funding, collateral requirements and cost of capital (Vaughan 2012; Watkinks, 2012). Equally, managers' statements provide evidence on the importance of credit ratings. As an example, on March 2016, Deutsch Bank CFO said in an interview: "the lender needs to move back into A ratings over longer term" (Keller, 2016).

In this paper, we argue that bank managers are concerned about credit ratings, due to the discrete cost associated with different credit levels. For instance, since institutional investors take in consideration credit ratings for their investment decisions, a downgrading event would result in a subsequent increase of funding costs. We establish that credit rating changes directly affect bank capital structures and capital adjustments decisions. However, banks might be reluctant to issue new equity and are likely to rely on internal sources to achieve target capital ratios. They could move to target capital ratios with two different strategies: shrinking of assets and funding adjustments. Consequently, the adjustment process following a downgrade is prone to affect both bank lending and funding decisions. We take in consideration these potential effects and we analyse also the impact of rating changes on lending and funding adjustment decisions.

To investigate the effect of rating changes on banks' capital adjustments, we use a data set drawn from Bloomberg on 76 banks based in the EU and the US over 2005Q1-2015Q4. The database combines banks' balance sheet and rating data on a quarterly basis. This allows us to analyse every capital structure adjustment that turns to be important for the market. We model capital ratios with variables capturing both the banks' target capital as well as the effect of adjustment costs and rating changes. More specifically, we readapt the partial adjustment framework with credit rating changes developed in Kisgen (2009) for non-financial firms.

We find that banks react asymmetrically to rating changes, increasing capital after downgrades but responding little after upgrades. This result implies that bank managers target a specific credit level, in a similar way as non-financial firms (Kisgen, 2006; 2009). The capital build-up process after a rating downgrade is mainly driven by earning retention, while reductions in risk weights seems to be related to other factors. Moreover, we find that downgrades impair the access to market funding and causes a shift from long-term funding to other funding sources. Deleveraging has potentially adverse effects if bank simultaneously engage in asset shrinking through cutting lending (Hanson et al., 2011). We then examine the effect of rating changes on bank lending and we find that banks reduce lending supply activities after a downgrade.

The sovereign debt crisis represents a major challenge to our empirical exercise, as sovereign credit risk feedback into the financial sector through the rating channel (BIS, 2011). The transmission mechanism is the following: owing to strong links between sovereign and banks, sovereign downgrades often lead to downgrades of domestic banks (Alsakka et al., 2014; Klusak et al., 2017; Huang and Shen, 2015). In fact, although the sovereign ceiling technically no longer exists, there is evidence that sovereign ratings affect the ratings of non-sovereigns (Borensztein et al. 2013; Almeida et al., 2017; Klusak et al., 2017) As an example, for Greece, Ireland and Portugal rating agencies have linked their downgrades of major banks to the sovereign declining creditworthiness (Moody's 2010a, 2010b; Standard & Poor's 2010a, 2010b). As banks' credit rating declines, their funding costs increase and their market access diminishes. The downward pressure on banks' ratings from Greece, Ireland, Italy, Portugal and Spain experienced during the sovereign debt crisis may have increased the effect of rating changes on capital structure and lending of banks from those countries. We quantify this incremental effect of bank downgrades by comparing banks from countries that experienced the sovereign debt crisis (treatment group) with banks from the other countries (control group). The ratings of the treatment group are affected disproportionately more than the ratings of the control group by macroeconomic shocks and constraints imposed by rating changes rather than bank fundamentals. We capture the asymmetric impact using a difference in difference estimator that compares changes in capital, funding composition and loan supply made by treated banks versus control banks around credit rating changes. We find that treated banks react strongly than non-treated banks following a credit rating downgrade. Treated banks are likely to increase more shareholders' funds to total funds and earnings retention following a credit downgrade. Moreover, the impact is greater on long-term funding and consequently on lending supply as treated banks experienced higher funding constraints that impaired lending supply activities.

A number of placebo and falsification tests suggests that the incremental effects are not confounded by other factors. Specifically, to rule out that our results are driven by rating changes and not only to the deterioration in macroeconomic fundamentals of Greece, Ireland, Italy, Portugal and Spain, we conduct a placebo test in which we replace the downgrade dummy variable with a crisis dummy that takes value one during the financial crisis and the sovereign debt crisis and zero otherwise. The result of the test confirms that the incremental effect of rating changes in the treated group is explained by rating changes. However, the identification strategy already addressed this possibility: the treatment group contains banks with a rating closer to the sovereign bound that should, a priori, be less sensitive to macroeconomic shocks than control banks. To further rule out that our results are driven by rating changes and the sovereign rating channel, we conduct a falsification test in which we analyse if the incremental effects were at work before the sovereign debt crisis. Again, the test confirms our previous results.

We provide several contributions to the literature. First, we add to the strand of empirical literature on the determinants of bank capital (Brewer et al., 2008; Flannery and Rangan, 2008; Gropp and Heider, 2010; Lindquist, 2004; Jokipii and Milne, 2008; 2011; Adrian and Shin, 2010;) and bank capital management (Berger et al., 2008; Lepetit et al., 2015; Memmel and Raupach, 2010; De Jonghe and Öztekin 2015). We add to this literature by studying the effect of credit rating changes on bank capital structure and lending. Research from the corporate finance literature demonstrates that ratings affect a firm's cost of capital (Kisgen and Strahan, 2010), capital structure decisions (Kisgen, 2006) and leverage adjustments towards the target leverage ratios (Kisgen, 2009). Moreover, in contrast to the studies cited above, the higher frequency of our data (quarterly data compared with yearly) enables us to estimate each bank's adjustment following rating changes, which turns to be important for financial markets.

This study is also related to the literature on the transmission of sovereign credit risk to the banking sector, in which the rating channel has not received higher attention. To the best of our knowledge only Alsakka et al. (2014) and Adelino and Ferreira (2016) investigate the existence of the rating channel through which the sovereign credit crisis spreads to the financial sector. Other works explore the transmission of sovereign risk to the banking sector. Acharya et al. (2014) provides evidence of a double feedback loop between sovereigns and the financial sector as a result of governments' implicit and explicit guarantees to the financial sector and holdings of sovereign bonds. Recent studies also examine the effect of banks' holdings of domestic sovereign debt on bank lending during the European sovereign debt crisis (Popov and Van Horen, 2015; Acharya et al., 2015; Becker and Ivashina, 2014).

This paper is organized as follows. In Section 2, we examine the importance of credit rating for bank capital structure. Section 3 contains the empirical methodology. Section 4 describes the data. In Section 5, we present the results. Section 6, we perform a battery of robustness checks. Section 7 concludes.

2. Literature review

2.1 The importance of credit ratings for bank capital structure

The fundamental hypothesis of this paper is that credit ratings matter for capital structure decisions of banks, due to the discrete costs (benefits) associated with different rating levels. The empirical investigation in this paper explores capital structure decision-making and lending following a rating change, with banks downgraded adjusting their capital structure through reductions in leverage, long-term funding and lending.

Credit ratings are significant for capital structure decisions of banks for at least three reasons: regulation on bond investments and funding cost associated, information content of rating and theoretical reasons in the context of existing capital structure theories. Bank ratings are an important determinant of the issuance cost of senior unsecured debt. Long-term debt is an important source of funding. According to the ECB (2016) and Van Rixtel et al. (2015) the amount outstanding of debt securities issued with an original maturity above one year is nearly 15% of total liabilities for European banks. The summary statistics in Table 2 confirms this empirical evidence for our sample of banks. In addition, the importance of long-term funding sources is further enhanced by the recent developments on banking supervision, such as the Basel III liquidity risk requirements and the European supervisory regulatory and Bail-in resolution framework. Rating downgrades generally cause banks to pay higher spreads on their bond funding, and may also reduce market access; if institutional investors that are restricted to investment grade bonds are forced to liquidate their holdings of bank bonds as their ratings fall below the investment grade threshold.

Credit ratings provide information on banks' riskiness through the cycle beyond other publicly available information. The evaluation process of rating agencies comprises information that is not publicly available. However, compared to other corporations, banks pose a particular challenge for credit rating agencies. Their asset structure and importance for financial stability determine the degree of external assistance, that obviously changes the shape of risk factors to which they are exposed. Due to the opaqueness of the banking sector, the judgments of the major rating agencies tend to disagree over time (Morgan, 2002). Moreover, the reliability and the quality of credit ratings tend to change over the business cycle (Hau et al., 2012). If bank ratings contain important information, they will signal bank overall credit risk. Thus, banks in the same rating group would be assessed similar default probabilities and associated yields for their bonds. Banks near a downgrade in rating will then have an incentive to maintain the higher ratings.

The importance of credit ratings is also theoretical. Kisgen (2007; 2009) shows the importance of credit ratings on capital structure decision frameworks for non-financial firms, including also a discussion of credit ratings in the context of existing capital structure theories, such as the trade-off and the pecking order theory. Roughly described the intuition is the following. The trade-off theory argues that firms will balance the benefits of tax shields and other benefits of debt against the cost of bankruptcy and other cost of debt to determine an optimal level of leverage. An implication of the trade-off is that a firm tend to move back toward its optimal leverage when it departs from it. If the rating-dependent cost (benefit) is material, managers will balance that cost against the traditional adjustment costs implied by the trade-off theory. In certain situations, the cost associated with a change in credit rating may result in capital structure adjustments that are different from that implied by the traditional trade-off theory factors. In other cases, the trade-off factors may out-weight credit rating considerations.

Capital structure theories were tested for banks in Gropp and Heider (2010), finding similarities between non-financial and financial firms. Moreover, a collection of works on bank capital management (De Jonghe and Oztekin, 2014; Lepetit et al., 2015; Berger et al., 2008;) adopts the partial adjustment models of Flannery and Rangan (2006). The partial adjustment framework implies that banks should adjust their capital structure based on the trade-off between the adjustment costs and the costs of operating with suboptimal leverage.

2.2 Determinants of optimal bank capital ratios

Theoretical (Diamond and Rajan, 2000; Allen et al., 2011; De Angelo and Stulz, 2015) and empirical research (Brewer et al., 2008; Flannery and Rangan, 2008; Gropp and Heider, 2010) have shown the existence and the determinants of banks' optimal capital ratios. From the analysis of the literature, we retrieve the following determinants of optimal bank capital ratios: profitability, asset risk, asset and liability structure, income structure, cost efficiency and macroeconomic controls. Profitability is a key determinant of bank capital. According to the pecking order theory funding extra capital is the most expensive choice, hence it may be easier to increase capital via earning retentions and weaker dividend payments (Flannery and Rangan, 2008). According to Jokipii and Milne (2011) the management of capital and risk are dependent on the size of capital buffer. For low capitalized banks the relationship between adjustments in capital and risk are negative, while for well capitalized ones it is positive. Regarding the speed of adjustment towards their target capital and risk level, the authors find that low capitalized banks adjust significantly faster than their better capitalized counterparts. Altunbas et al. (2011), Köhler (2015), Demirgüc-Kunt and Huizinga (2010) successfully demonstrated the impact of business models on risk from different perspectives. According to the authors, banks involved in non-income activities or attracting non-deposit funding are inclined to operate with higher leverage. Banks' chartered value has also an impact on capital buffers. Banks with higher chartered values might raise capital more easily and cheaply than their peers, implying less need of capital buffers (Berger et al.; 2008). On the contrary, Gropp et al. (2010) suggests that bank reputation and chartered value should be protected by larger capital buffers.

The macroeconomic cycle is also a determinant of optimal bank capital. Following Jokipi and Milne (2008), Lindquist (2004), Bikker and Metzemakers (2004) raising capital during economic downturns is much more difficult, thus banks might be forced to reduce their lending activities to meet rising capital requirements. Therefore, bank capital ratios can be viewed as countercyclical. Finally, according to De Jonghe and Öztekin (2015) the level of inflation is also important as it induces banks to hold less capital.

2.3 Determinants of long-term funding decisions

In contrast to the corporate finance literature, the empirical banking literature has not devoted much attention yet to the determinants of banks' long term debt. The theoretical and empirical investigations have mainly focused on deposits (Allen et al., 2014; among others) and short-term funding sources (Demirgüç-Kunt and Huizinga, 2010; among others). To the best of our knowledge only Van Rixtel et al. (2015) and Camba-Mendez et al. (2012) have investigated the determinants of long-term debt issuance. Gropp and Heider (2010) have shown that standard determinants of non-financial firms' leverage also apply to large EU and US banks. Therefore, we can hypothesize that the choice for long-term debt is shaped by various factors at the firm level, such as: credit and liquidity risk, profitability and capitalisation.

With regard to credit risk, banks might decide to change their funding structure through issuances of long-term debt to overcome deposit supply constraints derived by higher credit risk in their loan portfolios. Moreover, they might also have issued long-term debt securities to target the new liquidity rules, such as the Net Stable Funding Ratio (NSFR). Profitability is another determinant of bank bond issuance. More profitable banks can have easily access to bond markets. Leverage is also a determinant as stronger capital buffers might improve the ability of banks to absorb risk, thus highly capitalised banks can access easily to bond markets and consequently issue more debt securities. Furthermore, as demonstrated by Baker and Wurgler (2002) for non-financial firms, market timing is an important determinant of capital structure decisions. When policy interest rates are low, issuances of bank bonds are expected to rise.

2.3 Determinants of lending supply at the micro-bank level

Bank lending is influenced by a series of macro- and bank-specific factors. In our capital structure context, we are interested in identifying the effect of capital and funding constraints that will ultimately affect the supply of credit. To do so we derive a set of bank-level and macroeconomic determinants from the literature, that are likely to influence bank lending activities. More specifically, we identify four bank-specific covariates. The first variable of interest is capital. Various papers assess the impact of bank capital on loan supply (Gambacorta and Marques-Ibanez, 2011; Cornett et al., 2011; Carlson et al., 2013; Osborne et al., 2016) emphasising cyclical variation in bank leverage and risk-appetite. Secondly, according to Altunbas et al. (2011), bank risk conditions are important determinants of banks' ability to supply new loans. Thirdly, when funding liquidity risk materialized, banks with stable sources of financing continued to lend relative to other banks during crisis periods (Cornett et al., 2011). Finally, off-balance sheet exposure has also a large impact on lending. When borrowers drew on pre-existing commitments in large quantities, liquidity constraints grew up with the effect of reducing lending supply.

3. Empirical methodology

3.1 Partial adjustment model

We test the impact of rating changes on capital structure decisions using the partial adjustment framework formulated in Flannery and Rangan (2006) and modified in Kisgen (2009) to include rating effects of capital structure decisions for non-financial firms. In a partial adjustment model, the current capital ratio of a bank, $K_{ij,t}$, is a weighted average of its target capital ratio, $K^{*}_{ij,t-1}$ and the previous capital ratio, $K_{ij,t-1}$, as well as a random shock, $\varepsilon_{ij,t}$:

$$K_{ij,t} = \lambda K^{*}_{ij,t-1} + (1-\lambda)K_{ij,t-1} + \varepsilon_{ij,t} \quad (1)$$

In a frictionless world, all banks chose the target capital ratio ($\lambda = 1$), however in practice banks needs time to adjust their capital and assets to move toward the target ratio. Hence, each year a bank closes a proportion λ of the gap between its actual and target level. The larger the lambda (λ), the higher the ability of a bank to adjust its capital levels toward the target. The target capital is unobserved and not constant over time.

$$K^{*}_{ij,t} = \beta X_{ij,t-1} \quad (2)$$

Substituting the equation of target capital (2) into equation (1) yields the common partial adjustment model developed in Flannery and Rangan (2006), and implemented also in De Jonghe et al. (2015), Lepetit et al. (2015) and Berger et al. (2008) in the banking literature.

$$K_{ij,t} = \lambda\beta X_{ij,t-1} + (1-\lambda)K_{ij,t-1} + \varepsilon_{ij,t} \quad (3)$$

Following Kisgen (2009), we modify equation (3) to examine the incremental effects of rating changes by including rating changes dummies:

$$K_{ij,t} = \lambda\beta X_{ij,t-1} + (1-\lambda)K_{ij,t-1} + \phi_1 Downgrade_{i,t-1} + \phi_2 Upgrade_{i,t-1} + \partial_i + \partial_t + \varepsilon_{ij,t} \quad (4)$$

Where: $K_{ij,t}$ is the capital ratio defined as Tier 1 regulatory capital or alternatively shareholders' funds over total assets. $X_{ij,t-1}$ is a vector of banks and macro-specific determinants of bank optimal capital ratios; the vector includes: the ratio of non-performing loans over total loans (*NPL*) to proxy for asset risk, bank profitability (Return on assets, *Roa*), the ratio of deposits over total funding (*Deposits*), the ratio of non-interest income over the sum of interest and non-interest income (*Non-interest income*), the level of overhead costs to total revenues (*Cost income*), the ratio of total loans over total assets (*Loans*), the percentage change of consumer prices (*Inflation*), the percentage change of GDP of a certain country (*GDP growth*), the ratio of the sum of book value of liabilities and market value of equity to book of assets (*Tobin Q*). $Downgrade_{i,t-1}$ and $Upgrade_{i,t-1}$ are dummy variables equal to 1 if the bank was downgraded or upgraded in a specific quarter, respectively. We hypothesize that an upgrade should have no impact, while a downgrade will presumably accelerate a banks' adjustment toward its target capital structure. ∂_i are bank fixed effects and ∂_t are year fixed effects to control for unobserved time-invariant characteristic (Mackay and Phillips, 2005; Lemmon et al., 2008).

We capture the adjustment in long-term funding and lending using a similar dynamic model as in equation (4). More specifically, for long-term funding adjustments, we modify equation (4) as follows:

$$LT\ Debt_{ij,t} = \lambda\beta X_{ij,t-1} + (1-\lambda)LT\ Debt_{ij,t-1} + \phi_1 Downgrade_{i,t-1} + \phi_2 Upgrade_{i,t-1} + \partial_c + \partial_t + \varepsilon_{ij,t} \quad (5)$$

where: $LT\ Debt_{ij,t}$ is total long term debt over total debt. $X_{ij,t-1}$ is a vector of bank-specific and macroeconomic determinants of long-term funding, that includes: the net stable funding ratio (*NSFR*), the ratio of non-performing loans over total loans (*NPL*), the return on assets (*Roa*), total shareholders' funds over total assets (*Equity to Total Assets*), the percentage change of GDP by country (*GDP growth*), the base rate set by central banks (*Policy rates*), the percentage change of consumer prices (*Inflation*). *Downgrade* is a dummy variable which takes value one if the bank is downgraded in a specific quarter. *Upgrade* is a dummy variable which takes value one if the bank is upgraded in a specific quarter. ∂_c and ∂_t are country and time fixed effects, respectively. We control for country fixed effects instead of bank fixed effect, because during the crisis country-specific risk factors might be more relevant than bank-specific factors in determining long-term funding decisions (Van Rixtel et al., 2015).

To analyze the adjustments in lending supply, we modify equation (4) as follows:

$$Loans_{ij,t} = \lambda\beta X_{ij,t-1} + (1-\lambda)Loans_{ij,t-1} + \phi_1 Downgrade_{i,t-1} + \phi_2 Upgrade_{i,t-1} + \partial_c + \partial_t + \varepsilon_{ij,t} \quad (6)$$

where: $Loans_{ij,t}$ is total loans over total assets. $X_{ij,t-1}$ is a vector of controls, containing: Tier 1 capital divided by total risk weight assets (*Tier 1*), the ratio of non-performing loans over total loans (*NPL*), the level of balance sheet exposure over total assets (*Off-balance*), the net stable funding ratio

(*NSFR*), the percentage change of GDP of a certain country (*GDP* growth), the base rate set by the central banks (*Policy rates*). $X_{ij,t-1}$ contains also the interactions between the NSFR, the level of non-performing assets and the Tier 1 capital with the policy rates (*NSFR * Policy Rates, NPL * Policy Rates, Tier 1 * Policy Rates*). The interactions allow us to account for cyclicality in bank capital, liquidity and credit risk management.

3.2 Econometric issues of partial adjustment models

We estimate equations (4-6) using Blundell and Bond's (1998) system GMM estimates, since the model suffers from potential endogeneity of several right-hand side variables. To choose the appropriate instruments, we follow an identification strategy similar to Vallascas and Hagendorff (2013). Specifically, we use the first lag difference of bank characteristics as instruments in the level equation and the second and third lags of bank characteristics as instruments in the difference equation. With this set of instruments, we treat all bank characteristics as endogenous covariates, while treating macro controls and rating events as exogenous. The number of lags varies to ensure that the models pass both Hansen and second order autocorrelation tests.[14] Similarly to Lepetit et al. (2015), De Jonghe and Öztekin (2015) and Berger et al. (2008), in this study we employ the one step estimator, since the two-step tend to bias the estimated standard errors downward (Blundell and Bond, 1998).

According to Flannery et al. (2013), Blundell and Bond's (BB) estimation methodology should be the default choice under the conditions of potential endogeneity and dependent variable persistence in the context of capital adjustment models. However, the authors noticed that the fixed effect (FE) estimator is the most accurate with respect to the exogenous variables, but exhibits much higher errors for the lagged variables. The reliability of the FE estimator increases in longer panels. Taking into account the higher accuracy with respect of the exogenous variables and the properties of our dataset we test the results of the BB estimator with the fixed effect estimator.

3.3 Sovereign rating channel

Owing to strong links between sovereigns and banks, sovereign ratings often lead to downgrades of domestic banks. The dependence of banks rating on sovereign ratings has been evident during the sovereign debt crisis (BIS, 2011). The downward pressure on banks' rating intensified

[14] When augmenting the number of lags of the instruments, we take in consideration the threat that system GMM easily generate instruments that are numerous and suspect (see Roodman, 2009).

during the sovereign debt crisis due to the perceived decreasing ability of peripheral countries to provide support to their banking sectors. This in turn affected banks' funding costs and worsened their access to money and deposit markets. Therefore, credit rating downgrades have a different impact on banks that are headquartered in countries that experienced the sovereign EU debt crisis (treated banks) in comparison to banks headquartered in other countries (non-treated banks). We believe that the transmission of sovereign risk through the rating channel might increase the effect of bank credit rating changes, since banks from those countries have experienced the mentioned downward pressure on credit ratings. Based on our hypothesis, our treatment group consists of banks headquartered in countries with sovereign problems (Greece, Ireland, Italy, Portugal and Spain). Our control group consists of banks headquartered in non-stressed countries (Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Netherlands, UK, US). The choice is motivated by the fact that all banks in the treatment group experienced problems in accessing on market funding sources due to the spike in bond yields of their sovereigns during the period 2010-2012.

To measure the differential effect, we run ordinary least squares regressions (OLS) and estimate a difference-in-differences regression with the following form:

$$\Delta y_{ij,t} = \beta_1\left(Bank_i = Distressed\ Country_j\right) * Downgrade_{i,t-1} + \beta_2\left(Bank_i = Distressed\ Country_j\right) * Upgrade_{i,t-1} + \beta_3\left(Bank_i = Distressed\ Country_j\right) + \beta_4 X_{i,t-1} + \eta_t + \eta_c + \eta_i + \varepsilon_{ij,t} \quad (7)$$

where: $\Delta y_{ij,t}$ is the dependent variable that accounts either for capital adjustment *(*Δ*Tier 1*, Δ*Equity over total assets,* Δ*RWA and* Δ*Retained earnings*), long-term funding adjustment (Δ*LT Debt*) or lending (Δ*Loans*). $X_{i,t-1}$ are the same vectors of bank and macro controls defined in equations (4-6), η_t is a year fixed effect, η_c is country fixed effect and η_i is lender fixed effects. We implement specifications in which we replace year fixed effects and country fixed effects with country-by-year fixed effects ($\eta_c * \eta_t$), which absorb all shocks that are common to banks in a specific country in each year. The coefficients of the interaction terms $\left(Bank_i = Distressed\ Country_j\right) * Downgrade_{i,t-1}$ and $(Bank_i = Distressed\ Country_j) * Upgrade_{i,t-1}$ captures the difference in the reaction of treated versus non-treated banks following a downgrade and an upgrade event, respectively. Standard errors are clustered at the bank level.

4. Bank sample and rating data

We construct a panel of bank's ratings from January 2005 to December 2015 based on rating data from Standard & Poor's. We measure bank's rating with foreign currency long-term issuer rating, in which rating agencies use a sovereign's rating as an upper bound of issuer located in each country. We decided to rely on S&P's rating history for three main reasons. Firstly, S&P provide the most extensive coverage of bank ratings. Secondly, it demonstrates greater ability to revise and lead other agencies (Kaminsky and Schmukler, 2002, Alsakka et al., 2014). Thirdly, it seems that S&P ratings have a greater impact on the market since they are not fully anticipated (Reisen and von Maktzan, 1999; Adelino and Ferreira, 2016). We gather rating changes information from Bloomberg Professional Services and we retain the largest listed banks headquartered in Europe and the US. To avoid double counting ratings, we hold rating changes information at the highest consolidation level; for example, Santander UK is rejected while Banco Santander is retained. Information on rating downgrades and upgrades are translated into two distinct quarterly time series, with numerical value equal to one if a downgrade or upgrade occurs during that quarter, and zero otherwise. We also adjust our panel of rating changes for sovereign rating events. Alsakka et al. (2014), show the evidence of a sovereign rating channel, to which sovereign rating downgrades leads bank rating downgrades. Thus, we correct our data on rating events adding a numerical value equal to one in the case that a sovereign rating change anticipate bank rating changes.[15]

Rating data are matched through a text-string matching algorithm with quarterly accounting data from Bloomberg professional service. On Bloomberg, all financial information of EU and US listed banks are available. However, the selection of banks is further narrowed down by the availability of quarterly financial information data. Quarterly data allow us to estimate each bank's adjustment that turns to be important for the market, and better identify financing tensions associated with certain market and economic conditions.

After applying the criteria, the whole sample consist of 56 banks from 14 Euro area countries (AT, BE, CY, DE, DK, FI, FR, GR, IE, IT, NL, SP, SL, PT), UK, Sweden, and Switzerland and 20 banks from US. Appendix A provides the number of banks for each country and the number of rating changes observed. Our sample is well represented across countries in terms of national total banking assets and does not have over representation of smaller countries. Moreover, it includes all European and US globally important banks (G-SIBs) identified by the Financial Stability Board. Table 1 provides information on the definition, source and summary statistics of the variables used in our empirical investigation.

[15] In the dataset, we have not found any quarterly anticipation, since bank rating downgrades on average occurs a few days after sovereign downgrades. This is in line with Alsakka et al. (2014) that observes that S&P migrate bank ratings simultaneously with sovereign ratings.

[Insert Table 1 around here]

5. Results

5.1 Capital Adjustment

Table 2 reports the results of equation (4) with Tier 1 and shareholder funds to total assets as target capital ratios. We run the Blundell-Bond (1998) GMM estimator in columns (1) and (2), while in columns (3) and (4), we further validate our results with the FE estimator. In line with Gropp and Heider (2010), we include bank-fixed effects to control for time-invariant bank characteristics and time-fixed effects.

Results in Table 2 include dummy variables for whether banks were downgraded or upgraded in the previous quarter. With the BB GMM estimator the coefficient for the downgrade variable is economically and statistically significant at the 5% level with both target capital measures. This suggests that downgraded banks attempt to regain their previous rating through capital adjustment. This is consistent with our hypothesis of a link between credit ratings and capital structure decisions in the banking industry, and in line with Kisgen (2006, 2009) results for non-financial firms. The upgrade variable is not statistically significant different from zero in both regressions (1) and (2). This is also consistent with the credit rating-capital structure hypothesis because it indicates that bank managers do not attempt to reverse an upgrade, because it provides discrete benefits for the bank itself. According to our results, capital structure decisions are affected by whether banks were downgraded in the previous quarter as much as changes in profitability, credit risk or funding composition. With the fixed effect estimator, the coefficients on the credit rating downgrade remain significant for the equity to total asset ratio and insignificant with the Tier 1 ratio; while the coefficient on upgrades remains no longer significant.

The results reported in columns (1) and (2) also show the constant adjustment speed of the target capital ratios. The adjustment speed of the Tier 1 ratio is 0.30 per quarter (=1-0.693, where 0.693 is the coefficient of the lagged Tier 1 ratio), while the adjustment speed of the equity to total asset ratio is 0.33 (= 1-0.668, where 0.668 is the coefficient of the lagged equity to total assets ratio). The magnitude of the adjustment speeds varies across the two capital measures; banks adjust toward their target Tier 1 ratio slower than toward their Equity to total asset target. The result is in line with Berger et al. (2008), who finds that adjustments toward the target risk-weighted capital ratios are slower than the un-weighted counterpart. The magnitude of the adjustment speed parameter is in the range obtained for an international sample of banks (0.29 for banks worldwide in De Jonghe and Öztekin (2015) using system GMM) and large US banks (0.40 for U.S. Bank Holding Companies in

Berger et al. (2008) using system GMM). The magnitude of the adjustment speed is further confirmed in columns (3) and (4) with the FE estimator (0.268 and 0.25 for Tier 1 and Equity to total assets ratio, respectively).

Table 2 also reports the estimates of the bank-specific and country specific drivers of target capital ratios. With the Tier 1 target capital (columns 1 and 3), we find that only credit risk (NPL) and Tobin-Q are significant. More variables are significant with the non-weighted capital ratio, namely profitability, cost efficiency, deposit reliance and the non-interest income over total income are significant determinants of bank capital. This suggests that more profitable and cost efficient banks are more capitalized. Thus, as hypothesized by Flannery and Rangan (2008) and Gropp and Heider (2010), more profitable banks tend to hold higher capital buffers. Lower credit risk induces banks to hold less capital consistently with Jokipi and Milne (2011) and Nier and Baumann (2006). Higher deposits reliance and higher involvement in non-interest activities are positively associated with capital. The positive sign of the former variable might be related to the fact that deposits are prone to runs, thus banks tend to hold a buffer of capital to reduce information asymmetries and prevent runs from deposit holders. The sign of the non-interest income ratios is in line with the hypothesis that bank activities that generate non-interest income are riskier than traditional activities and thus require a higher capital cushion, as shown in Demirgüç-Kunt and Huizinga (2010). Regarding the macroeconomic determinants, in contrast with our hypothesis, we find a positive significant coefficient of the GDP growth variable. This suggests that capital ratios might be pro-cyclical, in the sense that banks use an expansionary macroeconomic environment to accumulate capital (Leaven and Majnoni, 2003; Schaeck and Cihák, 2012). Moreover, according to Brewer et al. (2008), during recessions defaults on bank loans increase and generate higher losses that are charged against bank capital.

[Insert Table 2 about here]

Banks can use different strategies to increase their capital ratios. According to Cohen and Scatigna (2016) the build-up of bank capital over recent years is mainly driven by earnings retention, while reductions in risk-weighted assets play a less important role. To analyse these different strategies that characterize the capital build-up process, we run model (4) with risk-weighted assets to total assets and retained earnings to total assets as dependent variables.

[Insert Table 3 about here]

Table 3 shows the results of the estimations. In column (1), we find that after a downgrade banks reduced their risk-weighted assets, suggesting that they shift from risky to less risky assets. However, we find a negative and significant coefficient also for the upgrade variable. The symmetric effect is in contrast with our predictions, since we expect an asymmetric effect similar to that observed with the target capital ratios. We believe that this progressive reduction in risk-weighted assets might be a consequence of the crisis and not an effect of credit rating changes.

As regard the control variables, in line with Vallascas and Hagendorff (2013), we find that risk-weighted increases with loans. In addition, we find a negative association with non-performing loans, suggesting that banks with a higher stock of bad loans are less prone to reduce risk-taking activities. In column 2 and 4, we find that earnings retention increases after a downgrading event. The coefficient of the downgrading variable is highly significant at the 5% level, while the upgrading coefficient is not statistically significant. The result is in line with the pecking order theory, as bank rely on earnings retention and weaker dividend payments to build up capital after a credit rating downgrade.

5.2 Funding Adjustment

Capital structure adjustments following downgrades might also affect the composition of bank funding. Banks may reduce their reliance on debt financing when they become riskier, such as following a downgrading event. However, during the financial crisis bond issuance might be affected by other factors. For example, banks that need to overcome liquidity constraints might have issued new debt securities even if the costs went up.

Table 4 shows that we find an economically significant negative relationship between long-term debt funding and rating downgrades. While, as expected the upgrade coefficient is not statistically significant for both the BB estimator and the FE estimator. This result, confirms our hypothesis that banks reduce long-term bond issuance after a downgrading event, due to the higher costs associated with lower ratings. Thus, downgraded banks suffer funding constraints due to impaired access to markets, higher collateral requirements and higher funding costs associated with rating triggers.

[Insert Table 4 about here]

The speed of adjustment of the long-term debt is 0.22 with the BB estimator and 0.176 with the FE, which is lower than that observed with in the capital adjustment regression (Table 2). The magnitude of the coefficient suggests that the shift in funding sources requires a longer time in comparison to capital adjustment decisions. With respect to the control variables, we find a negative sign for the NSFR and the level of non-performing loans, suggesting that banks with higher funding liquidity risk and credit risk issue less debt securities. One explanation might be that higher liquidity and credit risk increases the probability of distress and thus the cost and the access to the funding sources. In line with Van Rixtel et al. (2015) we find a positive sign of the performance variable (ROA), thereby supporting the hypothesis that more profitable banks have better access to financial markets. Finally, GDP and inflation enter with a positive significant sign, indicating that banks issue more debt securities in expansionary periods.

5.3 Lending adjustments

To estimate the impact of rating changes on lending supply, we estimate the partial adjustment model described in equation (6). Table 5 presents the results of the estimation. Column (1) includes the regression results using the Blundell-Bond estimator with year and country fixed effects, while column (2) contains the regression results using the FE estimator with year fixed effects. We find that, on average, a bank downgrade causes a reduction in lending supply. The coefficient of the downgrade variable is significant at the 5% level with both the estimation techniques. The upgrade dummy variable is not significant, suggesting that a bank upgrade has no impact on loan supply. As expected the speed of adjustment coefficient of loans has a small value, suggesting that interventions on the loan size take a long time to become effective. Regarding the bank-specific control variables (described in Section 3.2), we find that the level of non-performing loans, the net stable funding ratio and the level of regulatory capital are no longer significant. Off-balance sheet liquidity that materialized on the balance sheet constrained lending adjustment and reduced credit origination as in Cornett et al. (2011). Macroeconomic controls appear economically and statistically significant. As predicted, the coefficient of the GDP growth variable as a negative and significant sign, while the policy rate is significantly positive in line with Osborne et al. (2016).

Bank liquidity and capital ratios variables enter with a negative and significant sign when interacted with policy rates. This suggests that banks with a higher liquidity ratio are more sensitive to changes in monetary policy (Cantero-Saiz et al., 2014). Gambacorta and Marques-Ibanez (2011) also find that highly liquid banks tend to hoard liquidity for reasons of precaution rather than lend it out. The coefficient of the interaction term between the capital ratio and monetary policy is in line with the prediction of Adrian and Shin (2011), Borio and Zhu (2012) and Osborne et al. (2016), which emphasized the cyclicality of both leverage and bank willingness to accept risk.

[Insert Table 5 about here]

5.4. Sovereign rating channel

To further examine the importance of credit rating changes on bank capital structure and lending, we ask whether and, if so, how the sovereign risk channel has shaped the relationship. Bank's ratings from Greece, Ireland, Italy and Portugal experienced a downward pressure during the sovereign debt, so we question if the effect of rating changes on capital structure and lending is higher for banks from those countries. We quantify the incremental effect using equation (7).

Table 6 shows the estimates for the two target capital ratios, the variation of risk-weighted assets and retained earnings.

[Insert Table 6 about here]

The interaction term coefficient is statistically insignificant in columns (1) and (2), which indicates no asymmetric effects on the Tier 1 ratio. There is also no evidence of asymmetric effects on risk-weighted assets in column (5) and (6). However, columns (3) and (4) show that treated banks tend to increase more the unweighted capital ratio in comparison to non-treated banks. In addition, columns (7) and (8) show that the interaction term is positive and significant at 5% level, suggesting that treated banks retain more earnings than non-treated banks. We use the same bank and macro control variables as in Section 4.1 and we do not find any statistically different sign.

To examine the incremental impact of downgrades for treated banks on long term funding and lending, we estimate equation (7) using the change in long-term funding and lending as dependent variables.

[Insert Table 7 about here]

As shown in Table 7, treated banks show a higher reduction in long-term funding sources following a downgrade. In columns (1) and (2), the coefficients of the interaction terms are negative and significant at 10% and 5% level, respectively. We find the same effect on loan changes. Treated banks reduced lending more than non-treated banks following a downgrade. We estimate equation (7) using three different configurations. In column (3), we run the model without macro controls and we find a negative significant coefficient at the 1% level. In column (4,) we add the macro controls and we find the same level of significance. In column (5), to further take care of time-varying country conditions, we include country-year fixed effects instead of country and time fixed effects. The aim is to control for time-varying borrower demand and or quality at the country level and to alleviate the concerns that our results have simply captured changes in the demand for loans (Popov and Van Horen, 2015). The significance of the coefficient decreases, but the effect remains statistically and economically significant at the 5% level. The bank-specific and macroeconomic control variables in columns (3) to (5) are the same used in Section 4.

Overall, our findings show that the sovereign rating channel increases the impact of bank rating downgrades on capital, access to funding and lending supply. Although the results on the capital management are mixed, with the insignificant effect on the regulatory capital ratio and the level of risk-weighted assets, the impact on long-term funding and loan supply is statistically and economically relevant.

6. Placebo test

The first concern of our investigation is that the incremental effects of rating changes are driven by the financial and the European sovereign debt crisis, and thus are not a result of bank rating changes. If differences in balance sheet adjustments between treated and non-treated banks are indeed driven by the sovereign debt crisis, there should be similar adjustments between the two groups during the crisis periods. We control for this issue by performing a placebo exercise. In this first placebo exercise we create a crisis dummy with the following characteristics: equal to one in all countries of the sample during the financial crisis (period starting from the 3rd quarter 2007 to the end of 2009) and equal to one during the sovereign debt crisis (from 2nd quarter of 2010 to the end of 2012) in countries that experienced it (Greece, Ireland, Italy, Portugal and Spain), zero otherwise.

Table 8 shows that the differences in capital adjustments do not appear during the financial and the sovereign crisis without bank downgrades, as shown by the insignificant coefficients of the interactions terms (*Bank = distressed country *crisis*). The coefficient is statistically and economically significant only with the Tier 1 regulatory capital, indicating that regulatory leverage changes are mainly driven by the EU sovereign crisis. However, in Section 4 we do not find a significant effect of the downgrading coefficient on regulatory capital ratios. This reinforces our hypothesis that banks have maintained a higher regulatory capital to offset the shocks related to the crisis.

[Insert Table 8 about here]

In Table 9 we show the differences in funding and loan supply. As shown, the insignificance of the interaction coefficients confirms that the differential effect in funding and lending supply are a result of the two crises.

[Insert Table 9 about here]

To make sure that the sovereign rating channel drives the differences between treated and non-treated banks, we implement a second placebo test. In this exercise, we construct a triple interaction term. More precisely, we interact the variable *Bank = Distressed*Downgrade* with a dummy variable that takes value one before the sovereign debt crisis (from starting period to the 2nd quarter of 2010). The hypothesis that underlines the test is the following: if balance sheet adjustments between the two groups of banks are not driven by the sovereign rating channel, there should be a significant difference between the two groups in the period prior to the sovereign debt crisis.

The results of the placebo test shown in Tables 9-10 suggests that the differences between treated and non-treated banks do not appear in the period before the sovereign debt crisis. In particular, the triple interactions terms are no longer significant for capital adjustment regressions, funding and lending supply adjustments. This implies that the sovereign rating channel has driven the differences between treated and non-treated banks.

[Insert Table 10 about here]

[Insert Table 11 about here]

7. Conclusions

This paper examines the impact of credit rating changes on bank capital structure adjustments, funding decisions and lending. We find that credit ratings affect bank capital structure decisions. More precisely, rating downgrades trigger a reduction in leverage, rating sensitive sources of funding and lending. On the contrary, rating upgrades do not affect capital structure decisions of banks. In our investigation, we also analyse the asymmetric impact on bank rating changes for banks headquartered in Greece, Ireland, Italy, Portugal and Spain during the sovereign debt crisis. The results suggest an economical significant incremental effect of rating changes on banks based on those countries. In particular, we find that treated banks reduced leverage, long-term funding and lending more than non-treated banks following a downgrade. Robustness checks also confirm our results.

The broad results of our study are consistent with our hypothesis that banks managers are concerned with rating-triggered costs (benefits), due to the discrete cost (benefits) associated with different credit levels. Our paper supports the view that banks, like non-financial firms, target minimum credit ratings. Moreover, we support also the view that public debt management affects bank credit ratings through the sovereign ceilings, and not only through fundamentals. When a sovereign experienced a crisis, the downward pressure on its credit rating is transmitted to the financial sector; with the consequence of reducing banks' access to external funding sources and ultimately lending supply.

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Table 1
Variables definition and summary statistics

This table provides the definition and summary statistics of the variables used in the regressions. The sample consist of 76 banks corresponding to 3,300 observations during the 2005-2015 period.

Variable	Definition	Source	Mean	St Dev	Min	Max
Tier 1	Tier 1 capital divided by total risk weighted assets	Bloomberg	0.110	0.030	0.063	0.204
Equity Total Assets	Total Shareholders' Funds divided by total assets	Bloomberg	0.071	0.033	0.014	0.168
Roa	Return on Assets	Bloomberg	0.038	0.130	-0.14	0.054
Cost income	Total overhead costs to the sum of net interest income and operating income	Bloomberg	0.647	0.202	0.298	1.76
NPLs	Non-performing loans to total loans	Bloomberg	0.048	0.062	0.009	0.329
Deposits	Total customers' deposits divided by total funding	Bloomberg	0.596	0.188	0.138	0.858
LT Debt	Total long-term debt to total debt	Bloomberg	0.168	0.114	0.008	0.509
Non-Interest Income	Non-interest income to the sum of interest and non-interest income.	Bloomberg	0.328	0.177	-0.12	0.823
Tobin's q	The ratio of the sum of book value of liabilities and market value of equity to book value of assets.	Bloomberg	1.013	0.053	0.790	1.468
RWA	Risk weighted assets to total assets	Bloomberg	0.561	0.219	0.164	1.083
Off-balance exposure	Off balance sheet exposure to total assets	Bloomberg	0.295	0.087	0.002	0.505
Policy Rates	The base rate set by the central banks	Bloomberg	0.0014	0.003	-0.005	0.020
NSFR	The Net Stable Funding Ratio	Bloomberg	1.132	0.223	0.381	2.190
GDP Growth	The percentage of GDP growth	World Development Indicators	0.0093	0.025	-0.09	0.078
Inflation	The percentage change of consumer price index	World Development Indicators	0.017	0.014	-0.04	0.048

Table 2
Rating changes and capital ratio adjustments

This table shows the Blundell and Bond (1998) and the Fixed Effects estimation results on the effect of rating changes on the capital ratio adjustment, for a sample of 76 banks over the 2005-2015 period. In all regressions, we estimate the partial adjustment model described in equation (4) using alternatively the BB (1998) and the FE estimator. The target capital ratio is Tier 1 capital divided by total risk weighted assets in columns 1 and 3, and the total shareholders' capital divided by total assets in columns 2 and 4. *Upgrade (Downgrade)* is a dummy variable which takes value one if the bank is upgraded (downgraded) in a specific quarter. See Table 1 for variables definitions. All bank-specific explanatory variables, as well as the rating changes dummies are one quarter lagged. All specifications control for bank and year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Blundell-Bond		*FE*	
	(1)	(2)	(3)	(4)
	Tier 1	*Equity Total Assets*	*Tier 1*	*Equity Total Assets*
Downgrade	0.002**	0.001*	0.001	0.001*
	(1.92)	(1.72)	(1.16)	(1.87)
Upgrade	0.002	-0.002	-0.006	-0.002
	(0.13)	(-0.12)	(-0.41)	(-0.36)
Tier 1	0.693***		0.732***	
	(12.98)		(16.65)	
Equity Total Assets		0.668***		0.745***
		(13.48)		(20.07)
NPL	0.027**	0.017*	0.025**	0.015*
	(2.12)	(1.66)	(2.23)	(1.72)
Roa	0.012	0.133**	0.009	0.104**
	(0.26)	(3.21)	(0.19)	(2.74)
Deposits	0.008	0.021***	0.006	0.018***
	(0.94)	(3.32)	(0.69)	(3.40)
Cost Income	-0.001	-0.001***	-0.001	-0.001**
	(-0.10)	(-2.71)	(-0.11)	(-2.44)
Non-interest income	0.009*	0.006***	0.006	0.004**
	(1.88)	(3.12)	(1.34)	(2.02)
Loans	0.012	-0.005	0.009	0.005
	(1.29)	(-0.06)	(1.13)	(0.97)
Inflation	-0.067	-0.054	0.007	-0.027
	(-0.94)	(-1.14)	(0.18)	(-1.03)
GDP Growth	0.015	0.050**	0.011	0.049**
	(0.31)	(2.02)	(0.36)	(2.91)
Tobin Q	0.051**	-0.004	0.058**	-0.001
	(1.99)	(-0.29)	(2.81)	(-0.01)
Constant	-0.051**	0.009	-0.055**	0.0006
	(-1.93)	(0.54)	(-2.44)	(0.04)
λ	0.307	0.332	0.268	0.255
Bank fixed effects	YES	YES		
Time Fixed effects	YES	YES	YES	YES
Arellano-Bond test for AR (2)	1.30(0.193)	0.32(0.751)		
Hansen P-value	1	1		
R^2			0.778	0.940

Table 3
Rating changes risk taking and earnings retentions.

This table shows the Blundell and Bond (1998) and the Fixed Effects estimation results on the effect of rating changes on two different strategies of capital adjustment: risk-weighted asset reduction and earnings retention, for a sample of 76 banks over the 2005-2015 period. In all regressions, we estimate the partial adjustment model described in equation (4) using alternatively the BB (1998) and the FE estimator. The target variable in column 1 and 3 is the level of risk-weighted assets over total assets, while in columns 2 and 4 is the level of retained earnings over total assets. *Upgrade (Downgrade)* is a dummy variable which takes value one if the bank is upgraded (downgraded) in a specific quarter. See Table 1 for variables definitions. All bank-specific explanatory variables, as well as the rating changes dummies are one quarter lagged. All specifications control for bank and year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Blundell-Bond		*FE*	
	(1)	(2)	(3)	(4)
	RWA	*Retained Earnings*	*RWA*	*Retained Earnings*
Downgrade	-0.008*	0.002**	-0.009**	0.002**
	(-1.78)	(2.42)	(-2.29)	(2.51)
Upgrade	-0.012*	-0.006	-0.008**	-0.001
	(-1.75)	(-0.45)	(-2.27)	(-1.28)
RWA	0.832***		0.667***	
	(17.05)		(11.25)	
Retained Earnings		0.704***		0.810***
		(16.14)		(22.75)
NPL	-0.011**	-0.019**	-0.076*	-0.017**
	(-1.96)	(-2.88)	(-1.67)	(-3.11)
Roa	0.092	0.056	-0.075	0.029
	(0.96)	(1.31)	(-0.59)	(1.14)
Deposits	-0.012	0.015**	-0.009	0.013**
	(-0.64)	(2.07)	(-0.27)	(2.78)
Cost Income	0.0002	0.0002	0.002*	0.0002
	(0.26)	(1.62)	(1.68)	(1.23)
Non-interest income	-0.011	0.001	-0.001	0.001
	(-0.87)	(0.69)	(-0.10)	(0.50)
Loans	0.111**	-0.008	0.199***	-0.017
	(2.99)	(-1.07)	(3.31)	(-0.34)
Inflation	0.020	0.076	0.088	0.044
	(0.17)	(0.99)	(1.15)	(0.90)
GDP Growth	0.044	0.073*	0.007	0.055**
	(0.63)	(1.95)	(0.15)	(2.09)
Tobin Q	-0.021	0.029**	-0.102	0.028***
	(-0.41)	(2.72)	(-1.97)	(3.96)
Constant	-0.002	-0.030	0.217	-0.032***
	(-0.04)	(-1.52)	(3.04)	(-3.98)
λ	0.168	0.296	0.188	0.19
Bank fixed effects	YES	YES	YES	YES
Time Fixed effects	YES	YES	YES	YES
Arellano-Bond test for AR (2)	1.25(0.209)	0.01(0.992)		
Hansen P-value	1	1		
R^2			0.929	0.936

Table 4
Rating changes and long-term funding adjustments

This table shows the Blundell and Bond (1998) and the Fixed Effects estimation results on the effect of rating changes on long-term funding, for a sample of 76 banks over the 2005-2015 period. We estimate the partial adjustment model described in equation (4) using alternatively the BB (1998) and the FE estimator. The dependent variable is Total long term debt to total debt. *Upgrade (Downgrade)* is a dummy variable which takes value one if the bank is upgraded (downgraded) in a specific quarter. See Table 1 for variables definitions. All bank-specific explanatory variables, as well as the rating changes dummies are one quarter lagged. All specifications control for country and year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Blundell-Bond	*FE*
	(1)	(2)
	LT Debt	*LT Debt*
Downgrade	-0.005**	-0.004***
	(-2.56)	(-2.71)
Upgrade	0.004	-0.0007
	(1.09)	(-0.35)
LT Debt	0.775***	0.688***
	(13.99)	(6.45)
NSFR	-0.052***	-0.024*
	(-3.24)	(-2.20)
NPL	-0.009*	-0.007**
	(-1.62)	(-2.24)
Roa	0.111*	0.094*
	(1.91)	(1.62)
Equity Total Assets	-0.111	-0.023
	(-1.44)	(-1.31)
GDP Growth	0.247*	0.238**
	(1.89)	(2.38)
Policy Rates	-0.091	0.463
	(-0.23)	(1.53)
Inflation	0.577**	0.530**
	(2.56)	(2.59)
Constant	0.146***	0.072**
	(3.97)	(2.75)
λ	0.225	0.176
Country fixed effects	YES	
Time Fixed effects	YES	YES
Arellano-Bond test for AR (2)	1.00(0.316)	
Hansen P-value	1	
R^2		0.874

Table 5
Rating changes and lending adjustment

This table shows the Blundell and Bond (1998) and the Fixed Effects estimation results on the effect of rating changes on lending adjustment, for a sample of 76 banks over the 2005-2015 period. We estimate the partial adjustment model described in equation (4) using alternatively the BB (1998) and the FE estimator. The dependent variable is total loans over total assets. *Upgrade (Downgrade)* is a dummy variable which takes value one if the bank is upgraded (downgraded) in a specific quarter. See Table 1 for variables definitions. *NSFR * Policy Rates, NPL * Policy Rates, Tier 1 * Policy Rates* are the interactions between the NSFR, the level of non-performing loans and the Tier 1 capital and the policy rates, respectively. All bank-specific explanatory variables, as well as the rating changes dummies are one quarter lagged. All specifications control for country and year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Blundell-Bond	*FE*
	(1)	(2)
	Loans	*Loans*
Downgrade	-0.007**	-0.006**
	(-2.54)	(-3.42)
Upgrade	0.005	0.008
	(1.08)	(0.31)
Loans	0.950***	0.818***
	(34.22)	(27.31)
Tier 1	-0.030	0.019
	(-0.42)	(0.40)
NPL	-0.002	-0.002
	(-0.10)	(-0.60)
Off-balance	-0.004*	-0.002
	(-1.63)	(-0.25)
NSFR	0.015	0.004
	(1.48)	(0.83)
GDP Growth	-0.114*	-0.110**
	(-1.65)	(-2.59)
Policy Rates	8.277***	4.13***
	(3.43)	(3.28)
*NSFR * Policy Rates*	-3.963**	-1.609
	(2.49)	(1.51)
*NPL * Policy Rates*	-0.358	-0.490*
	(-1.09)	(-1.65)
*Tier 1 * Policy Rates*	-2.720**	-1.96***
	(-2.17)	(-3.23)
Constant	-0.02	0.105***
	(-0.78)	(4.54)
λ	0.05	0.017
Country fixed effects	YES	
Time Fixed effects	YES	YES
Arellano-Bond test for AR (2)	1.55(0.120)	
Hansen P-value	1	
R^2		0.982

Table 6
Rating changes and capital adjustment

This table shows the estimates of model 5 on the effect of a rating downgrade on Tier 1, Shareholder funds to total assets, Risk-weighted assets and earnings retention for banks from countries that experienced the sovereign debt crisis. The dependent variables in column 1-8 are measured as a percentage change between two quarters. *Bank=Distressed country * Downgrade* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis is downgraded in a specific quarter. *Bank=Distressed country *Upgrade* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis is upgraded in a specific quarter. Bank controls include: the ratio of non-performing loans over total loans (*NPL*), the return on assets (*Roa*), the ratio of deposits over total funding (*Deposits*), the level of overhead costs to total revenues (*Cost income*), the ratio of non-interest income over the sum of non-interest and interest income (*Non-interest income*), the ratio of total loans over total assets (*Loans*), the ratio of the sum of book value of liabilities and market value of equity to book value of assets (*Tobin Q*). Macro controls include: the percentage change of consumer prices (*Inflation*), the percentage change of GDP of a certain country (*GDP growth*). All independent variables, as well as the rating changes dummies are one quarter lagged. All specifications control for bank and country per year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively. Standard errors are clustered at the bank level.

	Δ*Tier 1*		Δ*Equity* / *Total Assets*		Δ*RWA*		Δ*Retained Earnings*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bank = Distressed country Downgrade*	-0.0003	-0.0004	-0.0015**	-0.0016***	-0.010*	-0.012	0.003**	0.003**
	(-0.27)	(-0.24)	(-1.92)	(-3.10)	(-1.57)	(-1.18)	(2.56)	(2.11)
Bank = Distressed country Upgrade*	-0.003	-0.004	0.009	0.002	-0.003	-0.003	-0.0007	-0.0008
	(-0.27)	(-1.55)	(0.47)	(1.29)	(-0.73)	(-0.47)	(-0.45)	(-0.45)
Bank = Distressed country	-0.002	-0.004*	-0.002***	-0.002***	0.014***	0.017***	-0.002	0.005
	(-0.67)	(-1.99)	(6.69)	(6.64)	(7.88)	(6.20)	(-0.68)	(0.17)
Bank Controls	NO	YES	NO	YES	NO	YES	NO	YES
Macro Controls	NO	YES	NO	YES	NO	YES	NO	YES
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES
Country x Time FE	YES	YES	YES	YES	YES	YES	YES	YES
R^2	0.079	0.129	0.148	0.113	0.064	0.098	0.107	0.245

Table 7
Rating changes, long-term funding and lending supply adjustments

This table shows the estimates of model 5 on the effect of a rating change on long-term funding and lending supply for banks from countries that experienced the sovereign debt crisis. The dependent variables in column 1-8 are measured as a percentage change between two quarters.
*Bank=Distressed country * Downgrade* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis is downgraded in a specific quarter. *Bank=Distressed country *Upgrade* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis is upgraded in a specific quarter. Banks controls in column 2 include: the net stable funding ratio (*NSFR*), the ratio of non-performing loans over total loans (*NPL*), the return on assets (*Roa*), total shareholder's funds divided by total assets (*Equity Total Assets*). Macro controls in column 2 include: the percentage change of GDP (*GDP growth*) of a certain country, the base rate set by the central banks (*Policy rates*), the percentage change of consumer prices (*Inflation*). Bank controls in column 3-5 include: *Tier 1*, *NPL, Off-balance* and the *NSFR*. Macro controls in column 4-5 include: *GDP growth, Policy rates,* interactions between the NSFR, the level of non-performing loans and the Tier 1 capital and the policy rates. All bank-specific explanatory variables, as well as the rating changes dummies are one quarter lagged. Specifications in column 1 and 2 control for bank and country per year fixed effects. In column 3 and 4 control for country and year fixed effects. In column 5 for country per year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively. Standard errors are clustered at the bank level.

	Δ*LT debt*		Δ*Loans*		
	(1)	(2)	(3)	(4)	(5)
Bank =Distressed	-0.005*	-0.005**	-0.008***	-0.007***	-0.007**
country Downgrade*	(-1.83)	(-2.37)	(-3.71)	(-3.31)	(-2.44)
Bank = Distressed	0.002	0.003	0.003	0.003	0.005
country Upgrade*	(0.58)	(0.77)	(0.82)	(0.91)	(1.07)
Bank = Distressed	0.004	-0.008	-0.003	0.003	-0.006
country	(0.80)	(-0.90)	(-0.45)	(0.35)	(-1.52)
Bank Controls	NO	YES	YES	YES	YES
Macro Controls	NO	YES	NO	YES	YES
Bank FE	YES	YES	NO	NO	NO
Country FE	NO	NO	YES	YES	NO
Time	NO	NO	YES	YES	NO
Country x Time FE	YES	YES	NO	NO	YES
R^2	0.0751	0.089	0.043	0.058	0.155

Table 8
Rating changes and capital adjustment: placebo shock

This table shows estimates of the effect of placebo periods on Tier 1, Shareholder funds to total assets, Risk-weighted assets and earnings retention for banks from countries that experienced the sovereign debt crisis. The dependent variables in column 1-8 are measured as a percentage change between two quarters. *Bank=Distressed country * crisis* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis times the crisis indicator. *Bank=Distressed country *Upgrade* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis is upgraded in a specific quarter. *Crisis* is a dummy variable that takes value one: during the financial crisis (3rd quarter 2007 to 4th quarter 2009) and in countries that experienced the sovereign European crisis in the period starting from 2nd quarter 2010 to 4th quarter 2012. Bank controls include: the ratio of non-performing loans over total loans (*NPL*), the return on assets (*Roa*), the ratio of deposits over total funding (*Deposits*), the level of overhead costs to total revenues (*Cost income*), the ratio of non-interest income over the sum of non-interest and interest income (*Non-interest income*), the ratio of total loans over total assets (*Loans*), the ratio of the sum of book value of liabilities and market value of equity to book value of assets (*Tobin Q*). Macro controls include: the percentage change of consumer prices (*Inflation*), the percentage change of GDP of a certain country (*GDP growth*). All independent variables, as well as the rating changes dummies are one quarter lagged. All specifications control for bank and country per year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively. Standard errors are clustered at the bank level.

	Δ*Tier 1*		Δ*Equity* *Total Assets*		Δ*RWA*		Δ*Retained* *Earnings*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bank = Distressed	0.005**	0.005**	-0.002	-0.0037	-0.005	-0.006	0.002	0.001
country crisis*	(2.86)	(2.83)	(-1.06)	(-1.55)	(-1.32)	(-1.26)	(0.16)	(0.35)
Bank = Distressed	-0.002	-0.004**	-0.002**	-0.002***	0.015***	0.018***	-0.0003	-0.001
country	(-0.69)	(-2.10)	(2.25)	(-5.57)	(7.37)	(6.22)	(-0.75)	(-0.30)
Crisis	-0.003**	-0.003	-0.0003	0.0011	0.014**	0.020**	-0.001	-0.002**
	(2.27)	(-1.54)	(-0.25)	(0.84)	(2.86)	(2.75)	(-1.26)	(-2.02)
Bank Controls	NO	YES	NO	YES	NO	YES	NO	YES
Macro Controls	NO	YES	NO	YES	NO	YES	NO	YES
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
R^2	0.083	0.127	0.097	0.149	0.066	0.103	0.10	0.248

Table 9
Rating changes, long-term funding and lending supply adjustments: placebo shock

This table shows the estimates of model 5 on the effect of a rating changes on long-term funding and lending supply for banks from countries that experienced the sovereign debt crisis. The dependent variables in column 1-8 are measured as a percentage change between two quarters. *Bank=Distressed country * crisis* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis times the crisis indicator. *Bank=Distressed country *Upgrade* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis is upgraded in a specific quarter. *Crisis* is a dummy variable that takes value one: during the financial crisis (3rd quarter 2007 to 4th quarter 2009) and in countries that experienced the sovereign European crisis in the period starting from 2nd quarter 2010 to 4th quarter 2012. Banks controls in column 2 include: the net stable funding ratio (*NSFR*), the ratio of non-performing loans over total loans (*NPL*), the return on assets (*Roa*), total shareholder's funds divided by total assets (*Equity Total Assets*). Macro controls in column 2 include: the percentage change of GDP (*GDP growth*) of a certain country, the base rate set by the central banks (*Policy rates*), the percentage change of consumer prices (*Inflation*). Bank controls in column 3-5 include: *Tier 1*, *NPL, Off-balance* and the *NSFR*. Macro controls in column 4-5 include: *GDP growth, Policy rates,* interactions between the NSFR, the level of non-performing loans and the Tier 1 capital and the policy rates. All bank-specific explanatory variables, as well as the rating changes dummies are one quarter lagged. Specifications in column 1 and 2 control for bank and country per year fixed effects. In column 3 and 4 control for country and year fixed effects. In column 5 for country per year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively. Standard errors are clustered at the bank level.

	Δ*LT debt*		Δ*Loans*		
	(1)	(2)	(3)	(4)	(5)
Bank =Distressed	0.003	0.002	0.003	0.005*	-0.003
country Crisis*	(0.35)	(0.11)	(1.07)	(1.86)	(-0.47)
Bank = Distressed	-0.004	-0.010***	-0.008	-0.003	-5.81
Country	(-1.57)	(-4.59)	(-1.23)	(-0.37)	(-1.38)
Crisis	-0.006*	-0.012**	-0.003	-0.004**	0.002
	(-1.28)	(-3.31)	(-0.36)	(-2.15)	(0.38)
Bank Controls	NO	YES	YES	YES	YES
Macro Controls	NO	YES	NO	YES	YES
Bank FE	YES	YES	NO	NO	NO
Country FE	NO	NO	YES	YES	NO
Time FE	NO	NO	YES	YES	NO
Country x Time FE	YES	YES	NO	NO	YES
R^2	0.083	0.112	0.03	0.038	0.103

Table 10
Rating changes and capital adjustment: differences prior the sovereign debt crisis

This table shows estimates of the effect of placebo periods on Tier 1, Shareholder funds to total assets, Risk-weighted assets and earnings retention for banks from countries that experienced the sovereign debt crisis. The dependent variables in column 1-8 are measured as a percentage change between two quarters. *Bank=Distressed country * downgrade*pre-EU Crisis* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis has been downgraded prior to the EU sovereign crisis. *Bank=Distressed country* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis. Bank controls include: the ratio of non-performing loans over total loans (*NPL*), the return on assets (*Roa*), the ratio of deposits over total funding (*Deposits*), the level of overhead costs to total revenues (*Cost income*), the ratio of non-interest income over the sum of non-interest and interest income (*Non-interest income*), the ratio of total loans over total assets (*Loans*), the ratio of the sum of book value of liabilities and market value of equity to book value of assets (*Tobin Q*). Macro controls include: the percentage change of consumer prices (*Inflation*), the percentage change of GDP of a certain country (*GDP growth*). All independent variables, as well as the rating changes dummies are one quarter lagged. All specifications control for bank and country per year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively. Standard errors are clustered at the bank level.

	Δ*Tier 1*		Δ*Equity* *Total Assets*		Δ*RWA*		Δ*Retained Earnings*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bank = Distressed country downgrade* pre-EU crisis*	0.002 (0.80)	0.0006 (0.18)	-0.001 (-0.15)	-0.0009 (-0.79)	-0.0009 (-0.15)	-0.005 (-0.61)	0.002 (1.42)	0.007 (0.24)
Bank = Distressed country	-0.002 (-0.65)	-0.004** (-2.01)	-0.002*** (4.65)	-0.002*** (-5.74)	0.014*** (7.63)	0.018*** (6.21)	-0.0003 (-0.72)	-0.001 (-0.12)
Bank Controls	NO	YES	NO	YES	NO	YES	NO	YES
Macro Controls	NO	YES	NO	YES	NO	YES	NO	YES
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES
Country x Time FE	YES	YES	YES	YES	YES	YES	YES	YES
R^2	0.078	0.12	0.109	0.148	0.062	0.103	0.102	0.242

Table 11
Rating changes, long-term funding and lending supply adjustments:
differences prior the sovereign debt crisis

This table shows the estimates of model 5 on the effect of a rating changes on long-term funding and lending supply for banks from countries that experienced the sovereign debt crisis. The dependent variables in column 1-8 are measured as a percentage change between two quarters. *Bank=Distressed country * downgrade*pre-EU Crisis* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis has been downgraded prior to the EU sovereign crisis. *Bank=Distressed country* is a dummy variable which takes value one if a bank from a specific country that experienced a sovereign debt crisis. Banks controls in column 2 include: the net stable funding ratio (*NSFR*), the ratio of non-performing loans over total loans (*NPL*), the return on assets (*Roa*), total shareholder's funds divided by total assets (*Equity Total Assets*). Macro controls in column 2 include: the percentage change of GDP (*GDP growth*) of a certain country, the base rate set by the central banks (*Policy rates*), the percentage change of consumer prices (*Inflation*). Bank controls in column 3-5 include: *Tier 1*, *NPL, Off-balance* and the *NSFR*. Macro controls in column 4-5 include: *GDP growth, Policy rates,* interactions between the NSFR, the level of non-performing loans and the Tier 1 capital and the policy rates. All bank-specific explanatory variables, as well as the rating changes dummies are one quarter lagged. Specifications in column 1 and 2 control for bank and country per year fixed effects. In column 3 and 4 control for country and year fixed effects. In column 5 for country per year fixed effects. P-values based on robust standard errors are shown in brackets. *, **, and *** indicate statistical significance at the 10%, 5% and 1% level, respectively. Standard errors are clustered at the bank level.

	Δ*LT debt*		Δ*Loans*		
	(1)	(2)	(3)	(4)	(5)
Bank = Distressed country downgrade* pre-EU crisis*	-0.010	-0.011	-0.009	-0.006	-0.007
	(-0.81)	(-0.79)	(1.54)	(-1.00)	(-1.59)
Bank = Distressed Country	0.005	-0.007	-0.006	0.002	-0.695
	(0.83)	(-0.79)	(-0.89)	(0.30)	(-1.63)
Bank Controls	NO	YES	YES	YES	YES
Macro Controls	NO	YES	NO	YES	YES
Bank FE	YES	YES	NO	NO	NO
Country FE	NO	NO	YES	YES	NO
Time	NO	NO	YES	YES	NO
Country x Time FE	YES	YES	NO	NO	YES
R^2	0.096	0.111	0.03	0.036	0.102

Appendix A.

Number of banks for each country and frequency of rating downgrades and upgrades.

Country	N. Banks	N. Downgrades	N. Upgrades
Austria	2	4	2
Belgium	1	3	2
Cyprus	1	3	0
Denmark	2	5	2
Finland	1	1	1
France	5	10	6
Germany	4	8	4
Greece	4	21	10
Ireland	3	14	6
Italy	10	54	9
Netherlands	3	7	3
Portugal	2	11	2
Slovenia	1	3	0
Spain	7	33	15
Sweden	3	3	6
Switzerland	2	5	2
UK	5	14	6
US	20	52	33
Total	76	251	109

Bank risk and lending supply during conventional and unconventional monetary policies

Alex Sclip

Department of Economics and Statistics
University of Udine
Via Tomadini 30A – 33100 Udine
sclip.alex@spes.uniud.it

Abstract

This paper examines the effect of bank risks on the transmission mechanism of monetary policy for a sample of 149 US banks over the period from 2007 to 2016. Using quarterly balance sheet data and employing a GMM approach to deal with endogeneity, I document that bank risk positions are relevant for the transmission mechanism through the bank lending channel during the FED Quantitative easing (QE) programmes. I conclude that QE programs helped banks to supply new loans through the reduction of bank risk conditions, as perceived by financial market investors. These results are relevant for the way monetary policy was conducted in response to the financial crisis, since QE programmes were effective in reducing the heterogeneous transmission of the monetary policy in the US.

Keywords: Bank risks, bank lending channel, unconventional monetary policy, Quantitative Easing

1. Introduction

This paper explores the importance of bank risk conditions in the transmission mechanism of monetary policy during conventional and unconventional monetary policy interventions for a panel of 149 US banks over the period from 2007 to 2016.

Traditional conceptualization of the bank lending channel (Bernanke and Blinder, 1988; Kashyap and Stein, 1995) are based on the ability of central banks to directly manipulate the level of deposits through their control of bank reserves and the money multiplier mechanism. The underlying mechanism is the following: monetary policy tightening causes a fall in deposit that forces banks to substitute deposits with more expensive forms of market funding, with the result of contracting loan supply. The examination of the traditional framework suggests that bank access and cost of market based funding sources is not relevant for the transmission mechanism.

However, financial innovation and the higher reliance of banks to wholesale funding sources have increased the importance of banks' access to external financing in the functioning of the bank lending channel. Financial system changes have led to a new theoretical framework (Bernanke, 2007; Disyatat, 2011) in which the bank lending channel works primary through the impact of monetary policy on banks' external finance premium as determined by their balance sheet strength. The main hypothesis of the new theoretical framework is that monetary tightening leads to a rise in the price of funding liquidity, which constrains lending activities. Banks' cost of funds is sensitive to their underlying financial health, thus riskier or banks in poorer conditions have to pay a risk premium on their uninsured deposits. The risk premium constraints banks' access on external financing and ultimately limit asset expansion and loan growth.

The financial crisis has made very clear that the perception of risk by financial markets is crucial to banks' access to finance. Following, the eruption of the crisis only banks with strong capital positions and higher reliance on stable funding sources were able to maintain their lending activities (Cornett et al., 2011), while liquidity dried for banks with a higher proportion of market based funding sources. The liquidity constraints, the inability to access to new freshly funding sources due to the higher balance sheet risks and the exceptional monetary policy interventions have made relevant the investigation on how investors' perception of bank risks influence the effectiveness of unconventional monetary policy interventions.

The importance of bank risk positions on the transmission mechanism in an environment with conventional monetary policy interventions is investigate in Altunbas et al. (2010), for a sample of EU banks. In this paper, I take a step further as I analyse the effect of unconventional monetary policy that are likely to change the relationship. Unconventional monetary policy interventions in response to the crisis, may have drastically reduced the importance of bank risk in the provision of new loans. QE programs helped banks to restore their lending activities by influencing both the supply and demand side of loans. On the supply side, QE reduces financing costs for banks through lower depository rates and higher value of assets on the balance sheet. While on the demand-side, it increases consumer demand through a wealth effect due to improvement in asset prices. In respect to this, the observation of the effect of QE programs on bank balance sheets give rise to the following research questions: Did QE helps riskier banks to reduce funding constraints and ultimately sustain their lending activities?

My investigation is related on a growing literature on the impact of unconventional monetary policy on bank lending behaviour. Previous works have shown that the Fed QE programs led to higher loan growth (Chakraborty et al., 2016) and risk taking within banks' loan portfolio (Kandrac and Schluche, 2016). My work takes a different perspective, as it shed light on the effect of bank risks on the transmission mechanism of QE programs. Specifically, I analyse if QE programs alleviates funding constrains of risky banks and ultimately support the production of new loans for those banks. To do so I use a dataset of US bank balance sheet items and banks' risk positions over the period 2007 to 2016 at quarterly frequencies. The estimation is performed using a similar approach of Altunbas et al. (2010). To tackle endogeneity problems from the interactions between bank risk and monetary policy, I use a GMM system with robust standard errors as suggested by Blundell and Bond (1998).

I achieve two main results that demonstrate the effects of the QE programs on lending. First, I show that bank risk positions matter for the supply of new loans. Then, I demonstrate that riskier banks have benefited more of the QE programs to support their lending activities. However, unconventional monetary policy actions have also a negative effect on bank profitability. Since QE reduces long-term yields, lending to deposit interest rate spreads fall making harder for banks generate interest income on new loans. This negative effect may hamper the effectiveness of the interventions. I also control for this effect and I find that the results remain virtually unchanged. In particular, bank's risk positions, together with the monetary policy interactions remain unchanged. Basically, I do not find evidence of a net interest income channel at work that could reduce the effectiveness of unconventional monetary policy interventions in US.

The remainder of this paper is organised as follows. The next section discusses the literature. Section 3 and 4 describes the data and the methodology, respectively. Section 5 and 6 presents the empirical results and robustness checks. The last section summarises the main conclusions.

2. Literature Review

My work is related to two different strands of literature. More specifically, my empirical investigation is related to recent works on the effect of quantitative easing QE programs on the bank lending channel ant to the literature on the effect of bank characteristics on the bank lending channel.

Most of the literature on the transmission mechanism of monetary policy through the bank lending channel focuses on environments with positive policy rates and standard monetary policy interventions. After the massive FED and ECB interventions in response of the global financial crisis, the literature has started to devote attention on the effect of large scale asset purchases from different perspective. Morais et al. (2017) provide evidence of credit supply spillovers from US and European banks to Mexico after Quantitative Easing (QE) interventions, while Di Maggio et al. (2017) looks at the re-financing and consumption choices. Kandrac and Schulsche (2016) assess the effect of QE on lending and risk-taking. The authors find that QE leads to higher loan growths and more risk taking within loan portfolios. Rodnyansky and Darmouny (2017) shows that banks with a large fraction of Mortgage Back Securities on their balance sheet expand lending more aggressively after QE1 and QE3 interventions.

A large number of studies have analysed the response of lending to shifts in monetary policy, depending on bank-specific characteristics. A tight in monetary policy causes a drop-in deposit (Drechsler et al., 2015, Choi and Choi, 2017), that forces banks to rely on other external funding sources. Raising external debt financing is difficult for banks with weak balance sheets, so their lending is more sensitive to monetary shocks. In this regard, bank balance sheet is measured in terms of capital, funding composition, liquidity, size and credit risk.

Bank equity capital plays part in the provision of new loans, owing to the existence of regulatory capital constraints and imperfect competition in the market for bank-fund raising. The recent empirical literature (Carlson et al., 2013; Gambacorta and Mistrulli, 2004; Osborne et al., 2016) shown a cyclical relationship between bank capital and lending, i.e. the relationship is stronger during periods of credit contraction and weaker during credit expansion. One of the possible explanations relates to the cyclical mechanisms on bank decision making that have emerged since the financial crisis. As risk measures tend to vary pro-cyclically (Borio and Zhu, 2012), bank willingness to accept risk exposure increases during periods of rapid expansion and decreases during credit contractions. Therefore, banks during the pre-crisis period, operated with low levels of capital and accepted relatively high portfolio risks. Then, during the financial crisis the same banks needed to reduce leverage and portfolio risk. Moreover, Carlson et al. (2013) also shown that the elasticity of bank lending with respect to capital ratios is higher for banks with capital ratios near the minimum regulatory requirements, suggesting a nonlinear effect of capital ratios on bank lending. Further, funding composition plays a role on the provision of loans. There is a closer connection between the conditions in the financial markets and banks' ability to raise funds from wholesale funding sources. Consequently, the reliance on those funding sources makes banks' incentive and ability to lend sensitive to investors' perceptions and overall financial market conditions. This means that the transmission of monetary policy depends on the funding composition of the banking sector. Ivashina and Scharfstein (2010) and Cornett et al. (2011) demonstrate that banks cut less lending during the global financial crisis if they were less dependent on short-term debt.

In addition to funding composition, exposures on off-balance sheet loan commitments plays a role in the provisioning on new loans. According to Kashyap et al. (2002) demand deposits and loan commitments offer to bank customers a similar service: liquidity on demand to accommodate unpredictable needs. Indeed, in a loan commitment, the borrower has the option to take the loan on demand over some specified period of time; therefore, loan commitments can turn to loans at any time when the borrower chooses to withdraw funds. Berger and Bouwman (2009) finds that half of the liquidity creation at commercial banks occurs through committed credit lines. Thus, banks should consider loan commitments in their liquidity risk practices and their management should impact the production of new loans. Moreover, monetary policy effects are different under a commitment relative to loans not made under a commitment. Morgan (1998) note that bank loans not made under a commitment slow after monetary policy tightening, while loans under commitment accelerate or remain unchanged.

Bank size also matters. Size proxies for a few sources of heterogeneity in the banking sector. The perception of bank credit risk depends on the size of the bank. Market participants perceive systemic banks as too-big-to fail and thus less risky than the smaller counterparts. Moreover, larger banks have an easier access to alternative funding sources to finance their lending activities, thus are less sensitive to monetary policy changes.

Finally, Altunbas et al. (2010) suggests that bank risk conditions need to be considered among the other balance sheet indicators. According to the authors, banks with lower default probabilities are better able to protect their loan supply activity from monetary policies and external shocks.

3. Empirical model

To test the hypotheses, I propose the following dynamic model:

$$\Delta Loans_{i,t} = \alpha \Delta Loans_{i,t-1} + \beta X_{i,t-1} + \gamma Fed\ Funds_{t-1} * X_{i,t-1} + SSR_{t-1} * X_{i,t-1} + T_t^1 + \varepsilon_{i,t} \quad (1)$$

The dependent variable $\Delta Loans$ measures the growth rate in loan supply for bank i in quarter t relative to quarter $t-1$ scaled by total assets. The vector $X_{i,t-1}$ represent the (lagged) five bank specific variables that I identify in the discussion of the literature: (1) capital, (2) deposit funding, (3) loan commitments, (4) asset size, (5) bank risk position. The first four bank specific variables are expressed in the following way: capital is the fraction of shareholders' funds to total assets, deposit funding is the ratio of total costumers' deposits over total assets and assets size is the logarithm of total assets.

The fifth bank-specific variable is the bank risk position, identified with two risk variables: the loan loss provision as a percentage of total assets (LLP) and the Bloomberg credit risk measure. The LLP is a standard ex-post accounting measure of credit risk (Altunbas et al., 2010). The second variable is the Bloomberg 1-year ahead expected default probability, which is a forward-looking indicator of credit risk computed by Bloomberg professional service using financial and market data. The methodology used by Bloomberg to estimate the 1-year ahead expected default probability is an improvement of the Merton distance to default model[16]. The bank specific covariates are interacted with both the conventional ($Fed\ Funds_{t-1}$) and the unconventional (SSR_{t-1}) monetary policy indicators. The interaction coefficients capture the effect of monetary policy changes in the supply of credit. Finally, the specification also includes time fixed effects T_t^1 to control for loan demand shifts.

The analysis performed in this paper are affected by endogeneity issues. Monetary policy affects credit supply of banks, but the situation of the banking sector can influence monetary policy as well. Moreover, monetary policy affects banks' funding composition as well. A central bank increase in interest rates causes a drop on deposits (Drechsler et al., 2015; Choi and Choi, 2017), that causes a substitution of deposits with wholesale funding sources. To deal with endogeneity concerns, I use the one step system GMM with robust standard errors (Blundell and Bond, 1998). In the estimation, I use the second and third lags of interaction variables as instruments in the level equation and the second and third lags of the bank-specific covariates as instruments in the difference equation.

[16] For further methodological details see Bloomberg Credit Risk DRSK white paper on the Bloomberg professional service terminal.

4. Data

The data used in this paper is from Bloomberg professional service. I first select all active banks headquartered in the United States. There were 1040 individual banks active in 2016Q3. I exclude all foreign-controlled banks and banks not subject to the Trouble Asset Relief Program (TARP), which leaves a sample of 251 banks. Further, I exclude banks with no balance sheet data for at least 4 years. The final sample consist of 149 individual banks.

I collect detailed financial information for all banks in the final sample at quarterly frequencies for the period 2007Q1 – 2016Q4. In particular, I collect balance sheet information on bank assets, deposits, capital and off-balance sheet loan commitments. I start from 2007 because default probabilities started to rise between 2007Q3 and 2009Q3 with the eruption of the global financial crisis. The period of analysis contains the three QE programs conducted by the Fed. More precisely, the timeline of the unconventional monetary policy interventions is the following. In November 2008, the Fed started the first QE program with securities purchases beginning in the following month. By the end of the first quarter of 2010 the first QE program had concluded, however due to the weaknesses of the U.S. economy the Fed Open Market Committee (FOMC) announced a new large-scale asset purchase program on November, 3, 2010. In September 2012 FOMC meeting announced a third QE program that ultimately ends in October 2014.

To measure conventional monetary policy actions, I use the official Fed funds target rate as in Choi and Choi, (2017) and Drechsler et al. (2015) among others. The Fed funds target rate set by the Federal Open Market Committee is, on my opinion, a better measure of the stance of conventional monetary policy than the three-months Libor rate, used in Borio and Gambacorta (2017); because the latter is also influenced by developments in liquidity risk in the interbank market. For unconventional monetary policy, I use the shadow short rate as developed in Krippner (2013a; 2013b). The shadow short rate reflects the effects that unconventional monetary policy actions have on the term structure of interest rates (Pericoli and Taboga, 2015). Using the shadow short rate instead of the central bank's balance sheet volume, as a proxy for measuring the effect of unconventional monetary policy actions, as the advantage of evaluating the different impact of different unconventional policy actions on the term structure of interest rates. However, the estimation of the shadow short rate is particularly difficult and have been so far only estimated with approximate methods. In this paper, I use the methodology developed in Krippner (2013a; 2013b) and I estimate the shadow short rate with the MATLAB code provided by the author.

[Insert table 1 about here]

5. Results

Table (3) presents the main results of the paper. The equations have been estimated using the GMM estimator. The results of the estimations passed both the AR (2) and the Sargan test. This confirms, respectively, that there is no second-order serial correlation in the first-difference residuals and that the instruments are valid.

Column 1 reports the estimates of the baseline regression (1). Column 2 shows the estimates of the baseline model, with a triple interaction to analyse the incremental effect of bank risk position for riskier banks on the supply of new loans. Column 3 reports the estimates of the baseline model in column 1 with an additional interaction to control for the pro-cyclicality of the risk measures.

The coefficients of the bank specific covariates demonstrate that the riskiness of the bank portfolio has a negative effect on the ability of banks to provide lending. Other things being equal, higher loan-loss provision (LLP) reduces profits and capital, thus the variable have a negative effect on lending supply. A similar and higher effect is detected for the Bloomberg default risk variable. The results suggest that bank risk position matter for the supply of new loans. As indicated, Bloomberg default risk is a forward-looking measure of credit risk that includes market perceptions of banks' credit risk. In this respect, there is evidence that investors are sensible to credit risk, thus a higher Bloomberg default risk limits the ability of banks to rise external funds. As a result, for riskier banks it would be difficult to raise public equity or debt in capital markets. In this respect, the empirical evidence shows that US investors in bank's debt are sensitive to bank risk (Flannery, 2001; Goyal, 2005). More precisely, the sensitivity is analysed for subordinated debt instruments and the results suggests that it would be difficult for riskier banks issue uninsured debt to finance their lending activities.

Moving to the other bank specific covariates and their interactions. I observe a statistically negative effect for commitment credit lines, reflective of the takedown demand of funds that move from off-balance to on-balance sheet accounts. This negative sign indicates that banks more exposed to pre-existing commitments tend to drop total credit production for liquidity risk management purposes. However, the coefficients of the interactions between commitment credit lines and both the conventional and unconventional monetary policy indicators are not statistically significant.

As expected, the interaction terms of capital, deposits and size with the fed fund rates have positive signs. In line with the bank lending channel literature, well capitalized banks with stable funding sources are better able to offset conventional monetary policy changes (Gambacorta and Mistrulli, 2004; Cornett et al., 2011; Ivashina and Scharfstein, 2010). The interactions of capital and size with unconventional monetary policy measures (SSR) have the negative expected sign, while for deposits the coefficient is not significant. The results are consistent with my expectations: also during unconventional monetary policy tools strong capitalized banks are better able to expand their lending activities.

I also analyse the effect of monetary policy on lending relative to the overall level of bank's risk. The interactions between the Bloomberg credit risk and the Fed funds rates indicates that the transmission of conventional monetary policy is not sensitive to banks' risk position. The result is in contrast with the findings of Altunbas et al. (2010), who find that the transmission mechanism is less effective for riskier European banks. For the transmission mechanism under unconventional monetary policy, I find, as expected, a statistically significant negative sign of the interaction between the Bloomberg credit risk indicator and the shadow short rate. The sign of the coefficient suggests that the transmission of unconventional monetary policy measures is more effective for riskier banks. Thus, riskier banks have benefited more of the quantitative easing programs to support their lending activities.

I confirm this result in column 2 with two triple interaction terms: $Bloomberg\ Default\ risk_{t-1} * Fed\ funds * high\ yield$ to measure the sensitivity of lending supply to conventional monetary policy changes of non-investment grade banks, and $Bloomberg\ Default\ risk_{t-1} * SSR * high\ yield$ to measure the sensitivity of lending supply to unconventional monetary policy changes of non-investment grade banks. The coefficient $high\ yield$ is a dummy variable which takes value one for banks classified non-investment grade in the Bloomberg credit risk measure[17]. The sign of the coefficient of the first triple interaction remains statistically insignificant, while the coefficient of the second is positive and statistically significant. The magnitude and the significance of the latter coefficient further proofs our assertion that riskier banks have benefited more of the quantitative easing programs to support their lending activities.

The effect of bank risk on lending may be different over the business cycle due to the diverse market perception of risk. Moreover, the loan loss provision could be used as a discretionary tool to smooth earnings over time (Cornett et al., 2009). Therefore, I have introduced two additional interaction terms in column 3. Firstly, I interact the growth rate in nominal GDP with the Bloomberg default risk measure and the loan loss provision. The idea is the following: if the market perception of risk is lower during expansionary phase of the cycle and vice versa during downturns as suggested in Borio et al. (2001), the coefficient of the interaction term would be negative. For the second interaction, I expect that banks that set aside provision during expansionary periods, are better able to absorb losses and thus they can continue their lending activity. The results displayed in column 2

[17] The Bloomberg credit risk measure is a transformation of the Bloomberg one year ahead default probabilities on a rating scale. Non-investment grade banks are those with a default probability higher than 0.5200%.

of Table (3) indicate that the interaction term of the loan loss provision with the business cycle indicator is positive and statistically significant, while the interaction of the Bloomberg default risk measure with the business cycle indicator is negative and not statistically significant. Other coefficients remain roughly unchanged. The positive sign of the interaction, suggests that banks that set aside provision in positive states of the economy, would been in a better position to absorb portfolio losses during downturns and continue their lending activities.

[Insert table 2 about here]

6. Controlling for the existence of a "net interest income channel"

Conventional monetary policy changes (i.e. reduction in interest rates) are typically associated with an increase of the yield curve and an increase in net interest income, which amplifies the transmission mechanism. On the contrary, unconventional monetary policy measures entail a flattening of the yield curve, which erodes future profitability and impairs the effectiveness of monetary policy measures on banks; especially those more exposed on loan activities. To this issue, Borio and Gambacorta (2017) indicates that monetary policy is less effective in a low interest rate environment, owing to a different behaviour of capital-constrained banks and heterogeneity in bank risk. Given the effect of unconventional monetary policy on net interest income, I assume that the net interest income channel could shape the relationship between lending supply and bank risk. If this assumption is true, I would expect a reduction of the significance and the magnitude of the coefficients measuring bank risk position when testing for the net interest income channel.

To test the net interest income channel, we modify equation (1) in the following way:

$$\Delta Loans_{i,t} = \alpha \Delta Loans_{i,t-1} + \beta X_{i,t-1} + \gamma Fed\ Funds_{t-1} * X_{i,t-1} + SSR_{t-1} * X_{i,t-1} + Nii_{i,t-1} + Nii_{i,t-1} * Fed\ Funds_{t-1} + Nii_{i,t-1} * SSR_{t-1} + T_t^1 + \varepsilon_{i,t} \quad (2)$$

Where: Nii is the ratio of net interest income to total assets, which measures the contribution of the net interest income to the formation of the return on assets. $Nii_{i,t-1} * Fed\ Funds_{t-1}$ and $Nii_{i,t-1} * SSR_{t-1}$ are the interaction of the net interest income with the Fed funds and the shadow short rate, respectively.

The results of the estimation are shown in table (3). For equation 2, I use the same estimation procedure of equation 1. More specifically, I rely on the same lags for instruments in the level and in the difference equation.

[Insert Table 3 around here]

I find that the estimated coefficients remain virtually unchanged. In particular, bank risk position variables together with the monetary policy interactions remain roughly unchanged. This result suggest that the net interest income channel do not shape the relationship between credit supply and bank risk during both conventional and unconventional monetary policy changes. For the interactions of the net interest income over total assets (Nii) with the fed funds rates and the shadow short rates, I do not find a statistically significant sign relationship. The result is in contrast with the empirical findings of Albertazzi et al. (2016) for European banks and Borio and Gambacorta (2017) for a sample of international banks.

Part of this could be explained by the reduction of borrowing costs that boosted the net interest margin.

7. Conclusions

The higher reliance on alternative funding sources have made banks more sensible on market perception of credit risk. The increase of investors' perception of bank risks during the financial crisis has severely hit banks with larger shares of market base funding on their balance sheets. In response to these weaknesses in the banking sector and with the aim of restoring liquidity and reducing market uncertainty, central banks around the world started large asset purchase programs. The unconventional monetary policy interventions helped banks to access to external funds through the reduction of market risk premia of uninsured deposit funding. In this paper, I analyse how bank risk positions influences bank credit supply following unconventional monetary policy interventions. Using a sample of US banks over the period 2007 to 2016, I find that bank risks plays an important role in the transmission mechanism of QE programs. More precisely, I demonstrate that riskier banks have benefited more of the QE programs to support their lending activities. To further enhance my results, I also control for the "net interest income channel" and I find that the results remain roughly unchanged.

My results provide important policy implications. Firstly, I show that the impact of monetary policy actions can be both amplified or attenuated depending on investors' market perceptions of risk of the banking sector. Secondly, the results suggest that, especially during stress periods, a close coordination between central bank monetary policy and supervisory activity is required with the aim of increasing the effectiveness of the transmission mechanism through the bank lending channel (Altunbas et al., 2010).

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Table 1
Variables definition and summary statistics

This table provides the definition and summary statistics of the variables used in the regression. The sample consist of 149 banks corresponding to 3373 observations during the 2007-2016 period.

Variable	Definition	Mean	Standard Deviation	Min	Max
Loans to Total Assets	Net loans divided to total assets	0.690	0.105	0.153	0.80
Commitment credit lines	The ratio of loans under commitment to total assets	0.358	0.271	0.111	0.99
Capital	Total Shareholders' Funds divided by total assets	0.071	0.033	0.014	0.168
Size	Natural logarithm of total assets	3.485	0.826	1.746	6.997
Deposits	Total customers' deposits divided by total funding	0.878	0.087	0.382	0.942
Bloomberg Default Risk	Bloomberg 1-year ahead default frequencies	0.422	0.265	0.111	0.987
LLP	The ratio of loan loss provision over total assets	0.003	0.003	0.001	0.31
Fed funds		0.008	0.015	0.0012	0.052
SSR	The shadow short rate	-0.953	2.443	-4.12	5.04
GDP	The level of GDP growth	1.37	2.57	-8.2	5
Unemployment	The level of unemployment	6.995	1.837	4.5	9.93
Nii	The ratio of net interest income over total income				

Table 2
Regression results

This table shows the Blundell and Bond (1998) estimation results of equation 1, for a sample of 149 over the 2007-2016 period. P-values based on robust standard errors are shown in brackets. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	(1)	(2)	(3)
$\Delta Loans_{t-1}$	0.092**	0.061	0.093**
	(2.07)	(1.40)	(2.09)
Bank characteristics			
$Commitment\ credit\ lines_{t-1}$	-0.084**	-0.069*	-0.084*
	(-2.04)	(-1.69)	(-2.02)
$Capital_{t-1}$	0.007	0.011	0.008
	(0.13)	(0.22)	(0.17)
$Size_{t-1}$	-0.054**	-0.043*	-0.55**
	(-2.05)	(-1.69)	(-2.07)
$Deposits_{t-1}$	-0.281	-0.165	-0.28
	(-0.97)	(-0.58)	(-0.96)
$Bloomberg\ Default\ risk_{t-1}$	-0.023***	-0.019***	-0.023***
	(-4.97)	(-5.71)	(-4.90)
LLP_{t-1}	-0.067***	-0.069***	-0.067***
	(-2.65)	(-2.34)	(-2.65)
Interactions			
$Commitment\ credit\ lines_{t-1} * Fed\ Funds$	-0.655	-0.51	-0.644
	(-0.13)	(-1.07)	(-0.13)
$Capital_{t-1} * Fed\ Funds$	0.078**	0.071**	0.076**
	(1.93)	(1.85)	(1.87)
$Deposits_{t-1} * Fed\ funds$	0.660***	0.355*	0.665***
	(2.60)	(1.69)	(2.62)
$Size_{t-1} * Fed\ funds$	0.077***	0.049**	0.077***
	(3.26)	(2.21)	(3.30)
$Bloomberg\ Default\ risk_{t-1} * Fed\ funds$	-0.772		-0.687
	(-0.84)		(-0.75)
$Commitment\ credit\ lines_{t-1} * SSR$	-0.005	0.003	-0.005
	(-0.32)	(0.14)	(-0.30)
$Capital_{t-1} * SSR$	-0.034**	-0.037**	-0.034**
	(-1.88)	(-1.94)	(-1.90)
$Deposits_{t-1} * SSR$	-0.025	-0.046	-0.028
	(-0.19)	(-0.34)	(-0.21)
$Size_{t-1} * SSR$	-0.017*	-0.020*	-0.018*
	(-1.65)	(-1.83)	(-1.56)
$Bloomberg\ Default\ risk_{t-1} * SSR$	0.003**		0.004**
	(2.02)		(2.05)
$Bloomberg\ Default\ risk_{t-1} * Fed\ funds * high\ yield$		-0.244	
		(-0.65)	
$Bloomberg\ Default\ risk_{t-1} * SSR * high\ yield$		0.003**	
		(2.40)	
$\Delta GDP * Bloomberg\ Default\ risk_{t-1}$			-0.006
			(-0.61)
$\Delta GDP * LLP_{t-1}$			0.014*
			(1.78)
Time Dummies	YES	YES	YES
AR (1)	0.000	0.000	0.000
AR (2)	0.198	0.336	0.181
Sargan Test	0.559	0.093	0.585
N. of observations	3373	3373	3373

Table 3
Regression results of the "net interest income channel"

This table shows the Blundell and Bond (1998) estimation results of equation 2, for a sample of 149 over the 2007-2016 period. P-values based on robust standard errors are shown in brackets. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	(1)	(2)	(3)
$\Delta Loans_{t-1}$	0.091**	0.090**	0.098**
	(2.08)	(2.07)	(2.40)
Bank characteristics			
$Commitment\ credit\ lines_{t-1}$	-0.078**	-0.081**	-0.075**
	(-1.94)	(-2.01)	(-1.89)
$Capital_{t-1}$	-2.369	-2.436	-2.957
	(-1.24)	(-1.28)	(-1.30)
$Size_{t-1}$	-0.048**	-0.048*	-0.053***
	(-1.88)	(-1.85)	(-2.10)
$Deposits_{t-1}$	-0.217	-0.217	-0.270
	(-0.78)	(-0.76)	(-1.03)
$Bloomberg\ Default\ risk_{t-1}$	-0.22***	-0.022***	-0.216***
	(-5.08)	(-4.81)	(-5.33)
LLP_{t-1}	-0.076***	-0.076***	-0.073***
	(-3.11)	(-3.01)	(-2.94)
Interactions			
$Commitment\ credit\ lines_{t-1} * Fed\ Funds$	-0.55	-0.392	-1.00
	(-0.12)	(-0.08)	(-0.23)
$Capital_{t-1} * Fed\ Funds$	0.099**	0.092**	0.078*
	(2.06)	(1.91)	(1.59)
$Deposits_{t-1} * Fed\ funds$	0.61**	0.615**	0.592***
	(2.47)	(2.49)	(2.72)
$Size_{t-1} * Fed\ funds$	0.073***	0.076***	0.071***
	(3.12)	(3.21)	(3.52)
$Bloomberg\ Default\ risk_{t-1} * Fed\ funds$	-0.859		-0.430
	(-0.99)		(0.55)
$Commitment\ credit\ lines_{t-1} * SSR$	-0.009	-0.009	-0.009
	(-0.54)	(-0.57)	(-0.59)
$Capital_{t-1} * SSR$	-0.069***	-0.068***	-0.064***
	(-3.26)	(-3.19)	(-3.23)
$Deposits_{t-1} * SSR$	-0.016	-0.018	-0.069
	(-0.13)	(-0.14)	(-0.59)
$Size_{t-1} * SSR$	-0.016*	-0.016	-0.021**
	(-1.50)	(-1.47)	(-1.92)
$Bloomberg\ Default\ risk_{t-1} * SSR$	0.004**		0.004***
	(2.30)		(2.40)
$Bloomberg\ Default\ risk_{t-1} * Fed\ funds * high\ yield$		-0.556	
		(-1.01)	
$Bloomberg\ Default\ risk_{t-1} * SSR * high\ yield$		0.003**	
		(2.22)	
Net interest income Channel			
Nii	2.365	2.433	2.945
	(1.23)	(1.28)	(1.30)
$Nii * Fed\ funds$	-2.640	-2.427	1.243
	(-0.65)	(-0.59)	(0.91)
$Nii * SSR$	0.35	0.036	0.213
	(1.38)	(1.41)	(0.59)
$Nii * Fed\ funds * Capital_{t-1}$			-0.124
			(-1.15)
$Nii * SSR * Capital_{t-1}$			0.006
			(0.24)
$Constant$	0.200	-2.885**	-2.459**
	(0.47)	(-2.80)	(-2.64)

Time Dummies	YES	YES	YES
AR (1)	0.000	0.000	0.000
AR (2)	0.183	0.165	0.136
Sargan Test	0.472	0.484	0.720
N. of observations	3373	3373	3373