Bank risks and lending outcomes: Evidence from QE

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Abstract

This paper investigates the impact of bank risk positions on their lending outcomes during quantitative easing (QE) interventions. We find that after the first and second round of QE, banks with lower default probabilities expand lending more in comparison to their risky counterparts. However, differences were no longer relevant in the third round of QE, which occurred at a time when the banking sector health was improved relative to QE1. Our findings suggest that bank riskiness is important for the transmission of unconventional monetary policy interventions.

Keywords: Bank Risks; Lending; Monetary Policy; Large Scale Asset Purchases; Quantitative Easing; Federal Reserve.

JEL Classification: G20; G21.

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1. Introduction

Does banking sector health impair the transmission of unconventional monetary policy interventions? And if so, what are the channels?. In response of the global financial crisis, the Federal Reserve (Fed) has kept the short-term interest rates to zero and taken Large Scale Asset Purchases (LSAPs) – also known as Quantitative Easing (QE). Since the end of 2008, three successive waves were implemented in periods characterised by different financial market conditions. The first round of QE (QE1), was undertaken at the height of the crisis when financial markets and institutions were under maximum affliction. The second round of QE (QE2) occurred during a period of normalization when credit market stress had already fallen significantly and the global environment outside the euro area was generally more buoyant; and the third round (QE3) was introduced after a prolonged period of low interest rates and at a time when the banking sector health was near the pre-crisis levels. Both QE2 and QE3 were introduced for improving the disappointing economic activity and the still relatively high unemployment.

In this paper, we explore the role of banks' risk on lending expansion.[1] The connection between monetary policy and bank risk, which reflects financial market evaluation on bank riskiness, is important, because an impaired transmission channel might originate in the funding market if some banks face regulatory and economic constraints to refinance their lending activities, even if monetary policy is expansive. The importance of banking sector health is further emphasised by the structural developments in bank funding markets (Dagher and Kazimov, 2015) along with marked-to-market accounting, that are likely to have increased the sensitivity of banks' ability to lend to financial market conditions.[2] Given these changes in the financial landscape, accounting variables alone may not be accurate for the assessment of

[1] In this study, we concentrate on lending volumes rather than the risk-taking channel of monetary policy as this latter cannot be analysed without access to restricted data on credit registers or syndicated loans.
[2] Adrian and Shin (2010) show that increased bank holding of market-sensitive securities along with expanded trading books had increased the sensitivity of banks' balance sheets to interest rates.

banks' ability and willingness to provide new loans. This is particularly true for large listed banks with considerable levels of non-insured deposit funding and marked-to-market securities in their security books. In this context, market default probabilities contain important information to assess banks' ability to raise funding in the financial markets.

As far as we know, we are the first to show a link between market probabilities of default and lending expansion during QE interventions. The topic is of relevance because it allows us to further understand the functioning of the transmission mechanism of unconventional monetary policies. It also complements previous studies that have documented a significant effect of QE on bank lending (Darmouni and Rodnyansky, 2017), firm investment (Chakraborty et al., 2020; Foley-Fisher et al., 2016), risk-taking (Kurtzman et al., 2018) and real outcomes in terms of: employment (Luck and Zimmermann, 2020) and household net worth and consumption (Di Maggio et al., 2020).

Our research framework is developed in three stages. In stage one we employ an event study analysis to detect a link between QE and bank risk positions through the analysis of stock market reactions on Federal Open Market Committee (FOMC) announcements of QE interventions. Our evidence reveals that during QE1 and QE2 the stock market rewarded less risky banks, while in QE3 the stock market reaction was higher for risky banks. In other words, riskier banks were more exposed to the negative shock that leads to monetary policy intervention than their non-risky counterparts.

These findings are central to understand the dynamics of lending expansion and the transmission channels behind the three QE rounds in the second and third stage of our empirical exercise. Based on stock market reaction, one would expect that during periods of market turmoil, low risk banks exhibit an advantage in comparison to their counterparts, due to their better ability to refinance their funding at a lower cost. While when financial market turmoil is over, risky banks would easily refinance their activities and thus expand their lending capacity.

In the second stage of our analysis, we explicitly test these assertions using a difference-in-difference (DiD) strategy in which we link market measures of bank risks with lending expansion. Banks are classified in a treatment group (those in the 75^{th} percentile) and in a control group based on their three-year ahead market probabilities of default before QE interventions. The effect of bank risk on lending expansion is visible for QE1, it is reduced for QE2, and for QE3 it appears no longer significant. Among the lending categories, differences across the two groups appear greater for Commercial and Industrial (C&I) loans, with treated banks substituting this lending category with Real Estate (RE) loans. Results remain robust to a range of robustness checks.

The final stage of our research framework allows us to unveil the mechanisms behind the different lending expansion between the control and treated group of banks. Specifically, we find evidence of a "funding channel" during QE1, in which banks in the control group enjoy a funding advantage in terms of lower funding costs relative to their counterparts in the treatment group. This advantage allows them to expand lending more, while treated banks retrenched their assets. QE3 was announced after a period of considerably lower interest rates and added further liquidity in the banking sector. In this situation, treated banks were able to expand their lending through a "liquidity channel" in which they swapped securities to expand their lending while keeping their assets fairly constant.

Our study contributes to a growing literature on the effect of LSAPs on economic outcomes. We add to this body of research in two ways. First, we focus on the importance of bank risk positions for the transmission mechanism over a period of unprecedented monetary policy interventions; and second, we document an unexplored channel of monetary policy that works through the market assessment of the stability of the banking sector. In a nutshell, our findings reveal that bank risk can expand or reduce the effectiveness of QE interventions thereby confirming the presence of interactions between financial sector stability and monetary policy interventions.

The remainder of the paper is organised as follows. Section 2 discusses the related literature and the institutional background. Section 3 describes the data used for the empirical analysis. Section 4 analyses the impact of QE interventions on stock returns. Section 5 presents the main empirical results and the robustness test. Section 6 investigates the channels through which QE works. Section 7 concludes.

2. Literature Review and Institutional Background

2.1 Selected Literature

This study is related to the literature on the bank lending channel of monetary policy. Most previous works focus on environments with positive policy rates and standard interventions, seeking to find heterogeneity in the transmission mechanism owing to banks' balance sheet characteristics. For example, there is a sizeable literature demonstrating that bank capital (Carlson et al., 2013; Gambacorta and Mistrulli, 2004; Osborne et al., 2017; among others), size (Kashyap and Stein, 1995) and funding composition (Dagher and Kazimov, 2015; Ivashina and Scharfstein, 2010; Cornett et al., 2011; Drechsler et al., 2017) play a role in the transmission of monetary policy.

With the adoption of unconventional monetary policy tools by many central banks around the world in recent years, the literature has sought to analyse the effectiveness of these monetary policy interventions from different perspectives. The key studies we build on are Darmouni and Rodnyansky (2017), Chakraborty et al. (2020), Kurtzman et al. (2018), Luck and Zimmermann (2020) and Di Maggio et al. (2020), who use an identification strategy that consists in exploiting variation in mortgage-backed securities (MBS) holdings to detect banks that are more affected by the QE intervention and analyse the impact of those interventions on: lending expansion, risk-taking and real economic outcomes. Darmouni and Rodnyansky (2017) document that QE1 and QE3 had an impact on credit expansion with commercial banks with higher MBS exposures increasing lending more than their less exposed counterparts. By focusing more on lending categories, Chakraborty et al. (2020) highlight a crowding out effect that MBS purchases had on the C&I lending exposed banks. More precisely, the authors find that banks that benefit more from MBS asset purchases increase mortgage lending and reduce C&I lending exposure. The unintended effect of this portfolio rebalancing is a decrease of investments for firms that borrow from exposed banks. Both studies are concordant and show that QE2 had no significant effects on credit expansion. The evidence of lending expansion during QE1 and QE3 is accompanied by lax lending standards and increased loan risk characteristics as shown in Kurtzman et al. (2018).

With respect to real economic outcomes, Luck and Zimmermann (2020) analyse the effect of QE intervention on employment. The authors find that banks with a higher share of MBS holdings refinanced relatively more mortgages after QE1, therefore increasing local consumption and employment in the non-tradable goods sector. While, during QE3 banks increased lending to firms and home purchase mortgage origination, leading to substantial increase in employment. Looking at the mortgage market in more detail, Di Maggio et al. (2020) provide evidence of an increase in refinancing activities in QE1, which led to an increase in household equity releases and consumption. Moreover, by exploiting mortgage market segmentation based on whether they are conforming or not to Government Sponsored Enterprise (GSE), the authors find that during QE1 banks with higher mortgage related losses originated fewer jumbo mortgages. The pattern is not observed in QE3 when the banking sector health had improved.

Other interesting papers that shed light on how quantitative easing works are those related to the impact of monetary policies on asset prices. The high-frequency event study by Chodorow-Reich (2014) analyses the impact of unconventional monetary policy on banks, insurance companies and money-market funds, documenting a strong impact on banks and life insurance companies related to the raising of the value of their assets. Krishnamurthy and Vissing-Jorgensen (2011; 2013) show the impact of MBS purchases and treasury purchases on asset prices and interest rate spreads. Importantly for our study, the authors detect possible channels through which asset purchases influence market prices and yields.

Our paper is closest to Darmouni and Rodnyansky (2017), Chakraborty et al. (2020) and Luck and Zimmermann (2020), who analyse the impact of QE on bank lending. However, unlike these papers that exploit variation in exposure on MBSs, we link balance sheet data with market data to investigate if Bank Holding Companies (BHCs)' risk drive lending production across the three QE interventions. Specifically, we question whether in addition to the purchase of assets by central banks, the health of the banking sector is important for the effectiveness of unconventional monetary policy interventions. We expect a different reaction from the three interventions. In times of market turbulence, as in the case of QE1, we expect market probabilities of default to play an important role for the transmission mechanism because riskier banks would face difficulties to rollover market-based funding and sustain their lending activities. On the contrary, if the LSAPs intervention is implemented in a period in which the banking sector health is restored, differences between risky and less risky banks would disappear because of an easier access, and cheaper cost of market-based funding for both groups of banks.

2.2 Institutional background on QE

On November 25, 2008 the Fed announced QE1. The aim was to stabilise the financial system and help restore the US economy hit by the subprime financial crisis. As part of this program, the Fed started buying different types of securities in December 2008, dividing the purchase into two major groups: $100 billion in direct obligations of GSEs and $500 billion in MBS guaranteed by government agencies: Fannie Mae and Freddie Mac. On March 18, 2009 the Fed increased these purchases and by the end of QE1 (March 2010), the Fed had bought $1.25 trillion of MBS, 175$ billion in federal agency debt and $300 billion of longer-term Treasury securities, with different maturities (7, 10 and 20 years).

Since this first tranche of QE did not produce the expected effects on the US economy, especially on GDP growth and employment, on August 10, 2010, the Federal Open Market Committee (FOMC) announced a second round of quantitative easing. Under QE2, the Fed carried out two major operations: 1) the purchasing of $778 billion of long-term Treasury securities; and 2) a maturity extension program (MEP) (announced on September 21, 2011), under which the Fed purchased a total of $667 billion Treasury securities with duration of more than 6 years, while selling an equivalent amount of securities with duration of less than 3 years, in order to flatten the overall yield curve and keep very low medium-long term interest rates.

Given the disappointing economic performance and the higher level of unemployment on September 13, 2012, the FOMC announced QE3. The Fed initially started to buy $40 billion of MBS per month, without giving the exact size of the entire program, but leaving this purchase as open-ended, and dependent on job market conditions. In December 2012, the Fed added the monthly purchase of $45 billion of longer-term Treasury securities. After improvements of the economy were achieved, on May 22, 2013 the Fed Chairman indicated the tapering of QE3, that was confirmed in the FOMC statement on June 10, 2013. In December, the Fed reduced the purchase amounts to $35 billion in agency MBS and $40 billion in Treasuries and the program ended in October 2014.

Table 1 summarizes the main monetary policy events from 2008 to the end of 2014.

[Insert Table 1 about here]

3. Data sources

The data used in this paper are collected from different sources. Balance sheet and income statement information are obtained from the FR Y-9C consolidated financial statements for bank holding companies (BHCs) collected by the Federal Reserve Bank of Chicago on quarterly basis. We match daily stock returns of publicly traded BHCs from the Center for Research in Securities prices (CRSP) using a crosswalk provided by the Federal Reserve Bank of New York. Market data on default probabilities is drawn from Bloomberg Professional Service and matched through the RSSD ID Number, which is also available in the Bloomberg Terminal[3]. The time period considered in this study spans from 2007Q4 until 2014Q1. Our sample contains 351 BHCs with available market default probabilities. These institutions are larger in respect to the total sample[4] of BHCs and represent 59.5% of BHC total assets as of 2007Q4. To adjust for outliers, we winsorize observations above the 99th percentile and below the 1st percentile. Table 2 provides the list of variables used together with their FR Y-9C identification codes for an easier replication of our work. Table 3 reports the summary statistics for the period under investigation: 2007Q4-2014Q1[5].

[Insert Table 2 about here]

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[3] On Bloomberg Professional Service it is possible to gather the RSSD ID code. However, this data is not always available and can occasionally be inaccurate. Therefore, after using the matching algorithm we manually check, bank by bank, the correct matching through both the legal name and the headquarter country.

[4] The 351 BHCs considered have on average 32bn of total assets in comparison to the mean 14bn of total assets of the entire sample of BHCs. In terms of capital, the mean BHC in the entire sample has 9.2% of capital over assets, while the 351 BHCs considered in this paper have on average 9.1% of capital over assets.

[5] We use data from 2013Q1 to 2014Q4 in the robustness check that considers the tapering period. Data from this time window is not employed in the main analysis. For this reason, in table 3 we report the summary statistics from 2007Q4 to 2014Q1.

[Insert Table 3 about here]

Banks' risk positions are measured by the Bloomberg 1-year ahead expected default probability (PD_1yr) and the Bloomberg 3-year ahead expected default probability (PD_3yr). These two indicators of company credit risk are computed by Bloomberg professional services with a methodology similar to Moody's KMV 1-year expected default frequency (EDF).[6] PD_1yr and PD_3yr are computed using financial market data, balance sheet information and Bloomberg's proprietary bankruptcy database. The main drivers of default are modelled using the Merton model (Merton, 1974) and adjusted with the methodology proposed by Bharath and Shumway (2008). More precisely, the Merton's distance to default model is supplemented with information from other financial filings that improve model performance.[7] We use the Bloomberg measure of default risk over other measures for at least three reasons. First, it is available for a relatively large sample[8] of financial companies, it is widely used by market participants, it relies on market and financial statement data instead of using only historical information and it is updated frequently. Second, its predictive performance is statistically tested using a large database on historical defaults. Third, it can be easily mapped with a credit risk measure, similar to a rating scale, provided by Bloomberg and further compared with credit ratings issued by credit rating agencies. Moreover, also other papers such as Altunbas et al. (2010) and Fiordelisi et al. (2011; 2013) use a similar variable (Moodys' EDF) to proxy for bank risks.

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[6] Credit risk metrics from Bloomberg professional service and from Moody's EDF are widely used by financial institutions, including central banks and regulators (see for example ECB, 2019).

[7] As a matter of fact, for each sector Bloomberg provides specific metrics that should be related to the credit risk of a firm. For example, for banks non-performing loans and the structure of funding are core metrics included. For further methodological detail see Appendix A and the Bloomberg Credit Risk DRSK white paper on the Bloomberg professional service terminal.

[8] As an example, S&P ratings are available for only 67 BHCs at the end of 2017.

Unlike bank-specific variables that reveal historical accounting information, the expected default probability reflects financial market assessment of bank riskiness, and thus the ability of banks to raise funds from the capital market. Less risky banks, i.e. with lower probabilities of default, are in a better position to do so because of their higher ability to absorb future losses. In this respect, Acharya et al. (2016) using different configurations of the Merton's distance to default, show that credit spreads in the corporate bond market are sensitive to bank risks. As a result, for riskier banks it would be difficult to raise uninsured debt or equity funds in the financial market to sustain lending activities especially during periods of market stress.

Looking at the cross-sectional variation in risk, the summary statistics in Table 3 reveals that PD_1yr, PD_3yr have a standard deviation of 0.049 and 0.065 a mean value of 0.01 and 0.029, respectively. Figure 1A plots the mean values of PD_1yr and PD_3yr used in this study.

[Insert Figure 1 about here]

It shows that banks' default probabilities started rising with the outbreak of the global financial crisis during 2007 through to the end of 2008. After QE1 average default probabilities decreased reaching pre-crisis levels during QE3. A further increase after QE2 is related to periods corresponding to tensions on EU sovereign debt crisis and the US debt ceiling (Chodorow-Reich, 2014). Banks' default probabilities appear sufficiently rigid over the period under study and this alleviates potential concerns that banks anticipate or strategically respond to the Fed's QE announcements through balance sheet adjustments aimed at reducing their default probabilities. This assumption is further reinforced by the fact that our chosen measure incorporates also financial market information that is difficult to be targeted by banks.

Banks with higher default probabilities differ across a number of balance sheet characteristics, as shown in a preliminary correlation analysis reported in Table 4.

[Insert Table 4 about here]

Risky banks are typically smaller, less capitalized and characterised by a higher share of wholesale funding.[9] While on the asset side, they have a lower exposure to less risky assets such as MBS and treasuries. This suggests two important considerations. First, differences in both the asset and the liability side may capture differences in BHCs' business models that can increase the exposure of some type of institutions to the policy event. Second, all regression models should control for the main disparities in terms of balance sheet characteristics that the previous literature found relevant for bank lending decisions. For example, Darmouni and Rodniansky (2017), Chakraborty et al. (2020), Kurtzman et al. (2018) and Luck and Zimmermann (2020), have shown that exposure to MBS drives the production of lending during both QE1 and QE3. Moreover, previous works that analyse conventional monetary policy interventions suggest that capital (Carlson et al., 2013; Osborne et al, 2016; among others) and size (Acharya et al., 2016) are important factors for the transmission mechanism.

4. Quantitative Easing and stock returns

We first analyse whether the stock markets valued banks according to their risk positions following QE announcements. Depending on whether market participants expected that QE interventions alleviated constraints on banks with higher (lower) risk, then we should expect a positive (negative) correlation between bank stock returns and market probabilities of default.

[9] Table A.4 in the Appendix reports the mean values of the BHCs' main balance sheet characteristics by risk quartiles.

There are several reasons why we should expect a different reaction of stock prices to announcements about QE based on bank riskiness. In the consumption-based Capital Asset Pricing Model (CAPM), investors derive utility from consumption and become more risk averse as asset prices decline and consumptions approaches the habit level (Campbell and Cochrane, 1999; Cohn et al., 2015). QE1 was announced in a period of market turmoil, when typically, investors' demand for long-term safe assets and highly rated corporate bonds increases. The higher demand drives down the yield of medium and long-maturity safe nominal assets, and the Fed's purchases reduce the supply of such assets hence increasing the equilibrium safety premium. QE1 also affected lower-grade corporate bonds through a reduction in default risk premium and a reduced prepayment risk premium, but with a lower magnitude (Krishnamurthy and Vissing-Jorgensen, 2011). Therefore, since the period from November 2008 to the beginning of 2009 was an unusual time of financial market turmoil, we expect that banks with lower default probabilities experienced higher stock returns over the announcement of QE1 and lower tensions in funding markets compared to their riskier counterparts.

A similar reaction, but with a smaller magnitude, should be expected in QE2. According to Krishnamurthy and Vissing-Jorgensen (2011), QE2 was not effective in stimulating the economy and during that period spreads rose for lower-grade bonds. Thus, one would presume that the stock market rewarded less risky banks given the market expectations that QE2 was not helping the economy generate a sustained recovery. The situation was different during the third round of quantitative easing, as interest rates were lower than in 2008 and the average banks' probabilities of default were near the pre-crisis levels. Figure 1A in the appendix shows that asset price responses to QE3 were lower in magnitude in comparison to those observed in QE1 (see also Krishnamurthy and Vissing-Jorgensen, 2013). We expect that increased market confidence decreased investors' risk-aversion leading to higher stock rewards for riskier banks.

We empirically test these predictions by regressing abnormal stock market returns on market default probabilities and other bank balance sheet covariates. This empirical exercise relies on the fact that the financial market did not fully anticipate the QE interventions. If FOMC announcements related to the QE were anticipated, then these anticipation effects would have reduced the impact of QE on stock returns. We proceed in the following way. First, we estimate Abnormal Returns (ARs) through a standard one factor market model (Mackinlay, 1997). Normal returns for every observation $R_{i,t}$ are obtained as a function of the market portfolio return $R_{m,t}$ represented by the S&P 500 portfolio:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \qquad (1)$$

Market model parameters are estimated with daily returns over a one-year time period that ends one month before the event date ($t = T - 395, \dots, T - 30$). Abnormal returns are then calculated as a difference between the actual stock return and the return predicted through the one-factor market model:

$$AR_{i,t} = R_{i,t} - \left(\hat{\alpha}_i + \hat{\beta}_i R_{M,t}\right) \qquad (2)$$

Mimicking the approach of Foley-Fisher et al. (2016) and Luck and Zimmermann (2020), we regress $AR_{i,t}$ of BHC on the day of the announcement of a given round of QE using the following regression model:

$$AR_{i,t} = \alpha + \beta PD_{3yr_{i,t-1}} + \vartheta X_{i,t-1} + \varepsilon_{i,t} \qquad (3)$$

where $AR_{i,t}$ is the risk-adjusted stock return on bank i on the announcement date t. PD_3yr_i is the three-year default probability of bank i averaged over the quarter prior to the QE announcement rounds. $X_{i,t-1}$ is a vector of bank-level controls of the quarter prior to the QE announcements.

[Insert Table 5 about here]

Table 5 shows the estimates of equation (3) on the announcement days of QE1 (column 1 and 2), QE2 (columns 3 and 4) and QE3 (columns 5 and 6). A higher default probability is associated with lower risk-adjusted returns in QE1 and QE2, while the opposite applies following QE3 announcement. These findings suggest that the market valued default probabilities in all of the three announcements beyond other important bank characteristics, such as: MBS, treasury exposure and leverage. The negative and statistically significant coefficient during QE1 confirms that highly rated firms benefited more from the announcement. To confirm this evidence, in Figure 2 we plot the spreads in the corporate market by different ratings. It shows that spreads between higher and lower rated bonds widened during the QE1 period. Moreover, as noted in He and Krishnamurthy (2013) the recovery of market premiums of low-grade bonds is slower in comparison to the high-grade bonds. The recovery in terms of market probabilities of default shows a similar pattern across risky and non-risky banks than that observed for corporate spreads. Figure 1.B reveals that market default probabilities for treated banks (those in the 75th highest percentile) take a long time to decrease in comparison to the control group.

Moving to the QE2 announcement, the main coefficient of interest decreases in magnitude, but remains negative and statistically significant confirming that tensions in the financial markets were alleviated in comparison to QE1.

Finally, for the QE3 announcement we document a different sign. At that time, interest rates and market premiums (see Figure 2) were lower than in 2008. Tensions in the markets were contained, therefore the stock market reacted differently and attached a higher value to riskier banks, possibly capitalizing on better growth opportunities for them to expand their lending activities. In support of this interpretation, Figure 1.B shows that during QE3 market probabilities of default slightly decreased for banks ranked in the 75th percentile of risk.

Taken together the results discussed in this section suggest that during QE1 and QE2, low risk banks were in a better position to expand their activities, due to the lower tensions experienced in the funding markets. Conversely, during QE3, when tensions in the funding markets were alleviated, risky banks capitalized on possibilities to expand their lending activities.

[Insert Figure 2 about here]

5. Bank risks and lending outcomes

In this section, we link lending expansion to bank probabilities of default in a difference in difference (DiD) framework. First, we describe the DiD setting and we estimate a static regression model. Then, we look at the timing of the effects by analysing in more detail the time-varying nature of the main coefficients. Finally, we perform some robustness tests.

5.1 Difference in Difference

In order to identify the effect of QE on banks' risk and lending, we employ a DiD strategy with a binary treatment variable. Our DiD setting is based upon endogenous variation in Fed's MBS purchases and price with cross-sectional variation among BHCs' market risks.

We build on the previous studies of Darmouni and Rodnyansky (2017) and Luck and Zimmermann (2020) and estimate the following model:

$$\Delta Loans_{i,t} = \alpha + \beta(Treat)_i^j * QE_t^j + \delta(MBS)_i^j * QE_t^j + \gamma X_{i,t} + \rho X_{i,t} * QE_t^j + \delta_i + \varepsilon_{i,t} \quad (4)$$

where the dependent variable, $\Delta Loans$ measures the growth rate in loan supply for bank i in quarter t relative to quarter $t-1$, and we also distinguish between Real Estate (RE) and Commercial & Industrial (C&I) lending categories. $Treat_i^j$ is a dummy variable with value 1 for banks from the highest 75th percentile of risk in the quarter prior to round $j = 1, 2, 3$ of QE, and 0 otherwise. QE_t^j is a set of dummy variables that takes value one for the different QE periods and zero otherwise.[10] Since existing literature (Darmouni and Rodnyansky, 2017; Luck and Zimmermann, 2020; Chakraborty et al., 2020) exploits a link between QE and bank lending through MBS exposure, we average MBS holdings to total assets $(MBS)_i^j$ over four quarters prior to round $j = 1, 2, 3$. To minimize endogeneity, the treatment dummy and the MBS holding are locked-in to the quarters prior to QE interventions, even though both variables are remarkably sticky over time. $X_{i,t}$ is a vector of bank controls that includes: size, capital over assets and treasuries over assets[11]. $X_{i,t} * QE_t^j$ are bank level controls interacted with QE dummies to allow for changes in relation to control variables and quantitative easing dummies. δ_i are bank fixed effects.

A concern for our empirical strategy relates to the distinction of supply and demand side effects. In the market for C&I loans, credit demand can be controlled through the use of loan

[10] More precisely: QE1 dummy is equal to one during the QE1 period (from 2008Q4 to 2010Q1), zero in all the other quarters; QE2 dummy is equal to one during the QE2 period (from 2010Q4 to 2011Q3), zero in all the other quarters; QE3 dummy is equal to one following the QE3 announcement (from 2012Q4 to 2013Q4), zero in all the other quarters.

[11] Bank controls are contemporaneous to the dependent variable. Prior related studies also use contemporaneous bank controls (Darmouni and Rodnyansky, 2017; Luck and Zimmermann, 2020; Chakraborty et al., 2020), although this can raise some endogeneity issues.

level data and exploiting the fact that firms can borrow from multiple banks. In the mortgage market separating supply and demand effects is more difficult than in the C&I loan market, given that households do not have relationship with more than one bank. In this case, one can only control for local demand for mortgage financing by exploiting the fact that multiple banks are active in the same county (Luck and Zimmermann, 2020). Unfortunately, we do not have access to loan level data, therefore we leave the control for supply and demand effects to future research. Another caveat of our empirical design is that the empirical assessment of macroeconomic policy is generally difficult, given the absence of a group that it is not directly influenced by the monetary policy interventions.

Before presenting the DiD results, we plot the average net lending growth (Figure 3A), the RE lending growth (Figure 3B), and the commercial and industrial lending growth (Figure 3C) of control and treated group over time. Figure 3A, shows that differences in net lending growth across the two groups widened during QE1 when the banking sector health was weak, while progressively diminishing in QE2 and QE3. Moving to the RE lending growth, differences remain stable during QE1 and QE2, while in QE3, they decreased substantially with treated banks starting to expand their lending activities. A similar patter, but with a slightly higher variation can be observed in Figure 3C for C&I lending growth. In this case, differences widened substantially in QE1 and remained stable in QE2. The pattern is again different in QE3, where treated banks started to expand their lending activities in this segment, which was not specifically targeted by the Fed interventions.

This preliminary exploration suggests a heterogeneity in the transmission mechanism owing to market risk. Specifically, it suggests that when market turmoil is higher, as in the case of QE1, banks with lower default probabilities are in a better position to sustain their lending activities. Heterogeneity is reduced when the banking sector health improved as in QE3 as treated banks started to expand their activities and reduce the gap with the control group.

[Insert Figure 3 about here]

In Table 6, we report the regression results of our DiD setting of equation (4). Results support our preliminary exploration. More precisely, the coefficient estimates for the interaction between the treatment variable (*Treat*) and QE1 are all negative and statistically significant. By comparing the magnitude of the coefficients, one can see that the coefficient for C&I lending is higher confirming that differences tend to be widened for lending categories not specifically targeted by the LSAP program. As QE1 focused on the housing market targeting MBS assets, risky banks were more encouraged to lend more in this market and crowding-out from the C&I market. This pattern is similar to that observed in Di Maggio et al. (2020) for the segmentation of the housing market. Specifically, the authors find a reduction in jumbo loans for risky banks, while the difference was not higher for conforming GSE loans. In this case, we noticed that the difference in lending outcomes across the treatment and control group widened for lending categories not targeted by QE programs.

Moving to $Treat * QE2$ coefficients, differences appear to be lower for net lending expansion confirming that tensions in the financial markets eased for treated banks. Moving to the RE lending segment, we noticed that the coefficient is roughly similar than that observed for QE1 interaction term in this lending category, while for C&I loans it is not statistically significant. The reason why we find a lower magnitude and significance of the coefficients of interest is related to the banking sector health at the inception of QE2, which was implemented to further improve economic conditions with a banking sector less troubled than in QE1. This interpretation is consistent with the findings of QE1, where we find that more constrained banks during that period were more likely to reduce C&I lending to support RE lending in order to alleviate capital charges.

Finally, the coefficients for the interaction term ($Treat * QE3$) are not significant in any of the specifications. This suggests that the heterogeneity in the transmission mechanism disappears in QE3. Before the announcement of QE3 the banking sector health had improved in comparison to QE1[12], in this context risky banks experienced a sudden drop in their market default probabilities that prompted them to expand their lending.[13]

[Insert Table 6 about here]

5.2 Timing of the effects

In section 5.1, we document that during QE1 and QE2 low risk banks experienced an advantage in terms of lending production in comparison to risky banks. However, in QE3, the difference across the two groups of banks was no longer significant. In this section we study the dynamics of these effects in more detail by estimating the coefficient on the exposure measure for each quarter individually. Within this analysis we are also able to understand if these effects, occurred after the policy event and not before. To do so, we estimate the following model:

$$\Delta Loans_{i,t} = \alpha + \beta Treat_i * D_t + \gamma X_{i,t} + \delta_i + \varepsilon_{i,t} \qquad (5)$$

where all variables are as defined in equation (4) above, the only difference being that we allow for the treatment dummy to vary across quarters. More specifically, we interact the treatment dummy ($Treat_i$) with a quarter indicator (D_t). The main coefficient of interest is β, which captures the difference across treated and control banks over quarters.

[12] Other metrics also indicate a slightly improvement in banking-sector health by the time of QE3. As an example, the TED Spread decreased from over 204bp (November 24, 2008) to 29bp (September 12, 2012).
[13] In table A.1 in the Appendix we provide the results of table 6 without controls. While in table A.2 we report the results of table 6 with the full set of controls displayed.

Figure 4 plots the main coefficients with 95% confidence intervals around them. We normalize β to zero in the quarter before the start of QE interventions. The three QE periods are marked with dashed lines. The estimates show no robust difference between the treated and control groups in the quarters prior the QE1 and during QE3.[14] Figure 4A displays estimates for different lending categories around QE1. The evidence for the aggregate net lending expansion shows that differences between the control and the treatment group progressively widened during QE1. The pattern is particularly evident for C&I loans where differences are gradually larger in magnitude, while they are smaller for RE lending. Figure 4B shows that after QE2 intervention the differences between the control and the treatment group progressively diminished. The pattern is similar for RE lending, whereas the estimates for C&I loans are insignificant and add some noise to the total lending expansion. Figure 4C reveals that in QE3 differences are close to zero and statistically insignificant.

[Insert Figure 4 about here]

These patterns are consistent with the results presented in section 5.1 and confirms the robustness of our previous assertions that the health of the banking sector is relevant for the transmission of unconventional monetary policy interventions. As regards the differences across the lending categories: it is important to note that differences in the C&I lending market, which was not targeted by the QE interventions, were higher and persistent around QE1. This indicates that treated banks were sufficiently constrained to substitute away from C&I lending during QE1.

[14] Table A.3 of appendix A reports the interacted coefficients ($Treat_i * D_t$) over time.

5.3 Robustness tests

In this section we perform three different robustness tests, related to concerns on: 1) the definition of the treatment group; 2) the tapering effect; 3) the event dates.

We start out by considering two alternative definitions for banks' riskiness. First, we modify the variable $(Treat)_i^j$ in equation (4) with a dummy variable equal to 1 for banks from the highest 75th percentile of risk two quarters prior to round $j = 1, 2, 3$. We do this to alleviate concerns that our measure is not sufficiently informative about bank's riskiness before the QE interventions. Results of the estimation are shown in column (1), (3) and (5) of Table 7 and confirm our main results documented in Table 6. Second, we use the one-year default probability to construct the $(Treat)_i^j$ indicator. In this case, the dummy variable is equal to 1 for banks from the highest 75th percentile of risk one quarter prior to round $j = 1, 2, 3$ of QE. Results are reported in columns (2), (4) and (6) of Table 7 and further confirm our main results in Table 6. Coefficient estimates remain roughly unchanged in terms of both statistical significance and magnitude.

Next, we investigate whether the tapering had an impact on lending activity across treated and control banks. We run equation (4) over the period starting from 2013Q1 and ending in 2014Q4 using tapering as an event. The tapering was announced on June 10, 2013 and implemented from January 2014, thus we create a dummy variable that takes value 1 after 2013Q4 and zero otherwise. In that period, banking sector health was similar to that observed in QE3, therefore we do not expect a significant sign for the interaction coefficient. Results of the estimation are reported in Table 8. The main variable of interest is not significant for total net lending growth and for both lending categories considered.

[Insert Table 8 about here]

Finally, we control for the event dates. Since we rely on quarterly data, event dates are by definition inexact. For example, as shown in Table 1, QE1 was officially announced in November 2008 and starts in 2009Q1. Therefore, one may be concerned that the effect of QE1 started in 2009Q1 and not in 2008Q4. Moreover, during the summer 2010 there were several rumours on a potential decision of the Fed to expand monetary stimulus. One may consider that markets anticipate the effect of the QE2 announced on August 10, 2010. In Table 9, we address these concerns by changing the QE event windows. Results remain qualitatively similar, as there are no significant effects even when moving the event dates.

[Insert Table 9 about here]

6. Channels

In this section we explore the balance sheet channels behind the effects of QE on lending across treated and control banks. Broadly speaking, asset purchases by the Fed can stimulate lending via balance sheet improvements at banks. We focus on three channels through which QE could affect bank lending outcomes: a "funding channel", a "liquidity channel", and a "net worth channel". First, changes to the short-term interest rates used by banks to refinance themselves are transmitted into funding costs. Non-standard monetary policy measures, such as the QE interventions, provide funding relief for banks in order to ease borrowing conditions in the non-financial sector. An improved funding position can in turn improve banks' subsequent ability to issue loans. The second way by which QE improve balance sheets is through increasing bank liquidity via acquisition of assets directly from banks' balance sheets. More precisely, such a "liquidity channel" works through a reallocation on the asset side of banks' balance sheets. As MBS become more liquid, banks can swap them for reserve and expand lending (Krishnamurthy and Vissing-Jorgensen, 2011; Rodnyansky and Darmouni, 2017). And finally, raising the price of securities in banking books, QE could generate a windfall gain for banks, improving their capital position via a “net worth channel”. An improved capital position reduces banks’ probability of default and in turn improves a bank’s subsequent ability to issue risky loans (Bigio et al., 2020).

We formally test these three mechanisms in Table 10. We first investigate the “funding channel”. As documented e.g., in Krishnamurthy et al. (2011), QE1 lowered yields of bonds which were considered safe (treasury, agency bonds and high-grade bonds) providing a substantial reduction in the default risk premium of corporate bonds. The reduction of default risk premium stabilised banks’ funding costs, in particular those of banks with lower market default probabilities. Notice that during QE1 there was considerable market turmoil and thus the demand for safe assets was greater, leading to higher benefits for less risky banks. While during QE2 and QE3 corporate risk premiums were compressed and the interventions worked mainly through increasing liquidity, which was more beneficial in terms of funding cost reductions for risky banks in comparison to the control counterparts. In other words, we test the hypothesis that bank funding costs after QE1 go down relatively more for less risky banks (control group) with these banks benefit from improved lending conditions (as shown in Figure 1), the opposite applies for QE3 when bank default probabilities were near the pre-crisis levels. The data seems to support the idea of a funding advantage being at play during QE1[15]. Figure 5 display the average wholesale funding costs for the treatment and control groups over the QE1 round. The figure shows a larger increase in funding costs for treated banks one quarter before QE1 intervention, with a slightly higher volatility in funding costs after the intervention.[16] We formally test this assertion in column 1 of Table 10, in which we run

[15] The assertion is also reinforced by the stock market analysis of section 4.1. As shown, the stock market valued more less risky banks during days around the QE1 and QE2 interventions, while in QE3 stocks of risky banks experienced a higher increase in value.

[16] Here wholesale funding costs are the ratio of the sum of interest paid on wholesale funding instruments (the sum of: interest expenses on time deposits above 100,000$ [bhcka517], expense on federal funds purchased and securities sold under agreements to repurchase [bhck4180] and other interest expenses [BHCK4398]) over

equation 4 using funding costs over total assets as dependent variable.[17] The positive sign of the $Treat * QE1$ interaction suggests that the control group experienced a funding advantage in comparison to the treated group that helped those banks to sustain their lending activities (as shown in section 5)[18]. In QE3 the situation changed: the interaction coefficient of $Treat * QE3$ is negative and statistically significant, suggesting a higher reduction in funding costs for risky banks in comparison to less risky counterparts. The channel behind QE3 is different and works through improved liquidity in the financial market. Before the intervention, tensions in financial markets were alleviated, with banks' probabilities of default near the pre-crisis levels (see Figure 1A and 1B). The lower probabilities of default and thus the improved funding conditions helped treated banks to sustain their lending activities in QE3 and thus differences across the two groups were no longer significant.

Given the improvement in funding costs during QE3, it is reasonable to ask how treated banks expanded their lending activities. To answer this question, we take advantage of previous studies on QE and lending outcomes, that provide evidence of a "liquidity channel" behind QE3. More precisely, the Fed did not purchase existing MBS but rather purchased MBS in the to-be-announced market. This means that it can improve bank liquidity via acquisition of MBS directly from bank balance sheets. Rodnyanksy and Darmouni (2017) finds that banks with large MBS exposure swap MBS for reserves and expand lending while keeping their asset fixed during QE3. Improved balance sheet conditions in conjunction with increased market liquidity in QE3, should give easier access to uninsured funding for treated banks – in comparison to QE1 and QE2 – allowing them to swap securities to expand lending. To test this version of the

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wholesale funding instruments (the sum of: brokered deposits [bhdma243 and bhdma164], time deposits of more than 100,000$ [bhdma242], foreign office time deposits [bhfna245], federal funds purchased in domestic offices [bhdmb993], securities sold under agreements to repurchase [bhckb995] and other borrower money [bhck3190]). The indicator is constructed following Choi and Choi (2020).

[17] We run the regression also with the wholesale funding cost indicator and the results (not displayed) were similar.

[18] Figure A.2 in the appendix provides a visual interpretation of the effect. More precisely, the figure show that banks that had a below median funding costs expand lending by more during QE1.

"liquidity channel", we run equation (4) using as a dependent variable the amount of securities sold under agreements to repurchase over total assets. The results of the estimation are presented in column 2 of Table 10 and confirm our prediction: treated banks swap more securities in comparison to the control group to expand their lending activities during QE3[19]. The additional liquidity obtained with the swaps is reallocated on the asset side through increasing lending activities, without increasing the asset side. To confirm the interpretation, in column 4 of Table 10 we regressed asset expansion and we observed that the interaction coefficient in QE3 is not statistically significant. Moreover, results in column 4 give us further confirmation of the lending retrenchment of treated banks during QE1 and QE2 that we document in the previous sections.

The third piece of evidence relates to the "net worth channel". In the previous sections we show that market probabilities of default decreased over time. The question that follows from this is how this reduction occurred. Fed asset purchase programs raises the prices of securities purchased, leading to windfall gains in values of banks MBS and Treasury security holdings, independently of whether these are sold (realized gains) or are still on the books (unrealized gains) increasing in turn the market-to-market value of equity. The key assumption behind the mechanism is well explained in Adrian and Shin (2010) who argue that since securities are priced mark-to-market – i.e., at their current market price – an increase in their value determines an increase in banks' equity values. Hence accounting effects can drive the increase in lending supply after a large asset purchase program, because of the relaxing of banks' credit constraints. Improvements in banks' capital positions lead to a reduction of banks' default probabilities that ultimately help banks to expand lending. This mechanism was described in Brunnermeier and Sannikov (2014) as "stealth recapitalization" effect of QE in a macroeconomic model.

[19] In figure A.3, we directly show that banks that swap more securities expand lending by more during QE3.

We test this channel in column 3 of Table 10 and find that there is no difference between the two groups around QE rounds. However, this channel is relevant only during QE1 for those banks with larger MBS exposures (result not displayed) confirming Rodnyansky and Darmouni (2017)'s findings. We believe that the "net worth channel" helped both groups of banks to recapitalize and reduce their default probabilities over QE1 and with a reduced effect during QE2[20]. The reduction in default probabilities to the pre-crisis levels at the inception of QE3 reduced the heterogeneity in the transmission mechanism across the two groups of banks. To confirm our assertions, in Figure 5A and 5B, we plot the level of Available For Sale (AFS) reserves over assets and the realized gains over assets across the two groups of banks over time. The figures show an increase in unrealized and realized gains on securities along the time span and most notably during QE1.

[Insert Table 10 about here]

7. Conclusions

In this paper, we analyse how bank risk positions influence bank credit supply following unconventional monetary policy interventions. By combining market data on bank risk positions and balance sheet data for large US BHCs and employing of a DiD setup, we find that risky banks – i.e. those with higher market probabilities of default – are in a worse position and are less able to expand their lending activities relative to their less risky counterparts during QE1 and QE2. For QE3, announced when banking sector health was slightly improved in comparison to QE1, we do not find a statistically significant difference in lending expansion across the two groups of banks. The heterogeneity observed in QE1 was explained by the "funding channel", in which risky banks were constrained to access uninsured funding to

[20] In figure A.4 we plot the average equity capital over assets of both group of banks over time. The figure show that both banks in the control and treated group recapitalized over time.

continue their lending activities. During QE3, funding costs decreased and helped treated banks to expand their lending activities. Lending expansion during QE3 occurred through an increase of securities swaps, without increasing total assets.

Our results provide important policy implications. Firstly, we show that the impact of monetary policy actions can be both amplified and attenuated by changes in the health of the banking sector. Thus, central bank monetary policy actions can have a different impact on the real economy depending on the financial sector balance sheet strength. In other words, an impaired transmission channel might originate in the funding market, because of funding constraints of some financial intermediaries. Secondly, our evidence suggests that, especially during stress periods, a closer coordination between central bank monetary policy and supervisory activity is needed to improve the effectiveness of the transmission mechanism through the bank lending channel.

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Table 1

Main Fed announcements

Date	FOMC announcement
November 25, 2008	QE1 announcement
March 18, 2009	QE1 additional expansion of QE1 and zero rates for "an extended period of time"
September 23, 2009	QE1 will finish at the end of Q1 2010
August 10, 2010	Announcement of QE2
September 21, 2010	Fed announced additional accommodation if needed
August 9, 2011	Announcement of zero lower bound through 2013.
September 21, 2011	Maturity extension program
January 25, 2012	Zero rates at least until 2014
September 13, 2012	Announcement of the zero lower bound "at least through mid-2015", and purchase of mortgage backed securities (QE3)
June 10, 2013	Fed announces it will start to taper longer-term treasuries and mortgage backed securities by the end of the year.
October 29, 2014	End of QE3 without raising fed funds rates

This table presents the main FOMC announcements from the end of 2008 to the end of 2014.

Table 2

Variable description

Variable name	Description	Source
Capital/Assets	The ratio of total equity divided by total assets [bhck3210/bhck2170]	FR Y-9C
Size	The natural logarithm of total assets [bhck2170]	FR Y-9C
MBS/Assets	The sum of MBS held to maturity and available for sale over total assets. [(bhckg300 + bhckg302 + bhckg304 + bhckg306)/bhck2170]	FR Y-9C
Treasuries/Assets	The ratio of Treasuries securities over total assets [(bhck0211 + bhck1286)/bhck2170]	FR Y-9C
Deposits/Assets	The sum of noninterest and interest bearing deposits of domestic and foreign offices over total assets [(bhdm6631 + bhdm6636 + bhfn6631 + bhfn6636)/bhck2170]	FR Y-9C
Total lending/Assets	Total lending over total assets [bhck2122/bhck2170]	FR Y-9C
Real Estate lending/Assets	The ratio of loans secured by real estate over total assets [bhck1410/ bhck2170]	FR Y-9C
C&I lending/Assets	The sum of commercial and industrial loans to US and non US addresses over total assets [(bhck1763+ bhck1764)/bhck2170]	FR Y-9C
ROA	Net income over total assets	FR Y-9C
Asset growth	The growth rate of total assets over a quarter	FR Y-9C
RE lending growth	The growth rate of real estate lending over a quarter	FR Y-9C
C&I lending growth	The growth rate of commercial and industrial loans over a quarter	FR Y-9C
Wholesale funding/Assets	The sum of wholesale funding instruments (the sum of: brokered deposits [bhdma243 and bhdma164], time deposits of more than 100,000$ [bhdma242], foreign office time deposits [bhfna245], federal funds purchased in domestic offices [bhdmb993], securities sold under agreements to repurchase [bhckb995] and other borrower money [bhck3190]) over total assets [bhck2170].	FR Y-9C
Funding cost/Assets	Total interest expenses over total assets [bhck4073/bhck2170]	FR Y-9C
Realized gains/Assets	Realized gains on available for sale and held to maturity securities over total assets [(bhck3196 + bhck3521)/bhck2170]	FR Y-9C
Unrealized gains/Assets	Unrealized gains on available for sale securities over total assets [bhck8434/bhck2170]	FR Y-9C

Securities sold/Assets	Securities sold under agreements to repurchase over total assets [bhckb995/bhck2170]	FR Y-9C
PD_1yr	Bloomberg 1- year ahead default probability	Bloomberg
PD_3yr	Bloomberg 3- year ahead default probability	Bloomberg

List of the variables used together with their definition and source. For bank balance sheet variables FR Y-9C codes used for the calculations are provided in brackets.

Table 3

Descriptive statistics

Variable	Mean	St. Dev.	p25	p75	Min	Max	Obs.
Panel A: Bank balance sheet controls							
Capital/Assets	0.095	0.026	0.081	0.111	0.030	0.183	9,935
Size	14.488	1.490	13.459	15.063	11.614	21.630	9,935
MBS/Assets	0.060	0.055	0.018	0.085	0.000	0.271	9,935
Treasuries/Assets	0.003	0.011	0.000	0.005	0.000	0.076	9,935
Deposits/Assets	0.786	0.081	0.746	0.842	0.467	0.902	9,164
Total lending/Assets	0.668	0.109	0.602	0.745	0.359	0.892	9,935
Real Estate lending/Assets	0.505	0.131	0.417	0.599	0.149	0.809	9,935
C&I lending/Assets	0.098	0.065	0.050	0.132	0.019	0.345	9,935
ROA	0.020	0.010	0.009	0.028	0.005	0.043	9,935
Wholesale funding/Assets	0.202	0.105	0.124	0.258	0.041	0.553	9,621
Asset growth	0.012	0.044	-0.010	0.025	-0.080	0.247	9,154
Total net lending growth	0.003	0.027	-0.014	0.021	-0.077	0.072	9,375
RE lending growth	0.095	0.043	-0.013	0.023	-0.078	0.075	9,465
C&I lending growth	0.012	0.089	-0.035	0.047	-0.123	0.158	9,445
Funding cost/Assets	0.008	0.007	0.003	0.011	0.001	0.032	9,935
Realized gains/Assets	0.001	0.001	0.000	0.0003	-0.005	0.004	9,621
Unrealized gains/Assets	0.0008	0.003	-0.0004	0.0028	-0.015	0.010	9,278
Securities sold/Assets	0.025	0.029	0.000	0.037	0.000	0.134	9,621
Panel B: Risk proxy variables							
PD_1yr	0.010	0.049	0.0001	0.003	0.000	0.033	8,394
PD_3yr	0.029	0.065	0.007	0.023	0.001	0.458	8,394

This table provides the summary statistics: mean, standard deviation, p25, p50, p75, minimum and maximum values of the variables used in the regressions. The sample consist of US BHCs over the 2007Q4-2014Q1. Bank balance sheet data comes from FR Y-9C data, risk proxy variables are from Bloomberg Professional Service.

Table 4

Correlation between market default probability and balance sheet characteristics

	(1)
	PD_3yr
Size	-0.003***
	[0.0003]
MBS/Assets	-0.050***
	[0.014]
Treasuries/Assets	-0.210***
	[0.033]
Capital/Assets	-0.933***
	[0.062]
Wholesale funding/Assets	0.016*
	[0.009]
R^2_{adj}	0.117

This table shows the regression estimates on default probabilities for different maturities on bank characteristics over the period of analysis. It reports coefficients and standard errors for each variable. Standard errors are robust and clustered at the bank level and reported in brackets. *,**,*** indicate significance levels at the 10%, 5% and 1% level, respectively.

Table 5

Announcement effects of QE1, QE2 and QE3

	(1)	(2)	(3)	(4)	(5)	(6)
	QE1		QE2		QE3	
PD_3yr	-0.246***	-0.268**	-0.079*	-0.089*	0.056	0.156*
	[0.093]	[0.134]	[0.045]	[0.050]	[0.085]	[0.084]
MBS/Assets		0.028		0.024		0.026
		[0.049]		[0.052]		[0.025]
Treasuries		0.029		0.172*		-0.114
		[0.265]		[0.101]		[0.082]
Size		0.004**		0.001		0.002***
		[0.002]		[0.001]		[0.001]
Capital/Assets		0.106		0.070		0.127**
		[0.174]		[0.099]		[0.059]
R^2_{adj}	0.070	0.099	0.027	0.046	0.002	0.133
Observations	150	150	151	151	153	153

This table shows the impact of market probabilities of default on stock returns on QE announcement days. It reports coefficients of a cross-sectional regression on daily stock returns on bank characteristics on: 25 November 2008 (QE1), 10 August 2010 (QE2) and 13 September 2012 (QE3). The dependent variable is the risk-adjusted return that controls for the market return using a one-factor model. Standard errors are robust and reported in brackets. *, **, *** denotes significance at the 10%, 5% and 1%, respectively.

Table 6

DiD Estimates

	(1)	(2)	(3)
	Total net lending growth	RE lending growth	C&I lending growth
Treat * QE1	-0.0062***	-0.0053**	-0.0219***
	[0.0016]	[0.0025]	[0.0056]
Treat * QE2	-0.0050***	-0.0044*	-0.0097
	[0.0019]	[0.0026]	[0.0065]
Treat * QE3	-0.0018	0.0051	0.0035
	[0.0020]	[0.0031]	[0.0067]
QE_t	Y	Y	Y
Bank controls	Y	Y	Y
Bank controls * QE	Y	Y	Y
Bank FE	Y	Y	Y
R^2_{adj}	0.275	0.170	0.105
Observations	7,005	7,296	7,284
BHCs	350	351	351

This table shows the regression results of equation (4) for the different lending categories for the period 2007Q4-2014Q1. In column 1, the dependent variable is the total net lending growth, in column 2 is RE lending growth, while in column 3 is the C&I lending growth. QE_t denotes the triple of QE dummy variables. Bank controls include: size, MBS over assets, Treasuries over assets and capital over assets. See Table 2 for variables description. Regressions use bank FE as specified. Standard errors are robust and reported in brackets. ***,**,* denotes significance at the 1%, 5% and 10% level.

Table 7
Different treatment indicator

	(1)	(2)	(3)	(4)	(5)	(6)
	Total net lending growth		RE lending growth		C&I lending growth	
Treat * QE1	-0.0047***		-0.0028*		-0.0133***	
	[0.0018]		[0.0029]		[0.0065]	
Treat * QE2	-0.0090***		-0.0100***		-0.0121*	
	[0.0018]		[0.0026]		[0.0067]	
Treat * QE3	-0.0064		0.0029		0.0117	
	[0.0023]		[0.0036]		[0.0078]	
Treat(1yr) * QE1		-0.0059***		-0.0073***		-0.0194***
		[0.0015]		[0.0024]		[0.0052]
Treat(1yr) * QE2		-0.0079***		-0.0068**		-0.0101*
		[0.0017]		[0.0023]		[0.0064]
Treat(1yr) * QE3		-0.0023		0.0029		0.009
		[0.0018]		[0.0027]		[0.0059]
QE_t	Y	Y	Y	Y	Y	Y
Bank controls	Y	Y	Y	Y	Y	Y
Bank controls * QE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y
R^2_{adj}	0.276	0.271	0.171	0.174	0.104	0.099
Observations	7,005	7,005	7,296	7,296	7,284	7,284
BHCs	350	350	351	351	350	351

This table shows the regression results of equation (4) for the different lending categories for the period 2007Q4-2014Q1. In columns 1, 3 and 5 *Treat* is a dummy variable equal to one if a bank probability of default is on the 75th percentile two quarter before the QE interventions. In columns 2, 4 and 6 *Treat*(1yr) is a dummy variable equal to one if a 1-year bank probability of default is on the 75th percentile one quarter before the QE interventions. QE_t denotes the triple of QE dummy variables. Bank controls include: size, MBS over assets, Treasuries over assets and capital over assets. See Table 2 for variables description. Regressions use bank FE as specified and interacted bank controls with QE dummies. Standard errors are robust and reported in brackets. ***,**,* denotes significance at the 1%, 5% and 10% level.

Table 8

Tapering

	(1)	(2)	(3)
	Total net lending growth	RE lending growth	C&I lending growth
Treat * Tapering	-0.0022	-0.0042	-0.0142
	[0.0021]	[0.0040]	[0.0103]
Bank controls	Y	Y	Y
Bank controls * Tapering	Y	Y	Y
Bank FE	Y	Y	Y
Quarter FE	Y	Y	Y
R^2_{adj}	0.366	0.246	0.116
Observations	2,426	2,644	2,636
BHCs	350	350	350

This table reports the estimates of equation (4) during the tapering of QE3 for the different lending categories. The period considered starts in 2013Q1 and ends in 2014Q4. Treat is our treatment indicator as defined in equation 4. Tapering is a dummy variable that takes value 1 after 2013Q4, zero otherwise. Regressions use bank controls, bank controls interacted with tapering dummy and bank and quarter fixed effects. Standard errors are robust and reported in brackets. *,**,*** denotes significance at the 10%, 5%, and 1% level.

Table 9

Event dates

	(1)	(2)	(3)
	Total net lending growth	RE lending growth	C&I lending growth
Treat * QE1 (2009Q1)	-0.0064***	-0.0054**	-0.0272***
	[0.0016]	[0.0026]	[0.0056]
Treat * QE2 (2010Q2)	-0.0059***	-0.0079***	-0.0088
	[0.0019]	[0.0024]	[0.0067]
Treat * QE3	-0.0019	0.0022	0.0014
	[0.0020]	[0.0031]	[0.0067]
QE_t	Y	Y	Y
Bank controls	Y	Y	Y
Bank controls * QE	Y	Y	Y
Bank FE	Y	Y	Y
R^2_{adj}	0.287	0.172	0.114
Observations	7,005	7,296	7,284
BHCs	350	351	351

This table reports the estimates of equation (4) for the different lending categories for the period 2007Q4-2014Q1. In comparison to the estimates shown in table 6, in this table we move the event windows. In column 1, the dependent variable is the total net lending growth, in column 2 is RE lending growth, while in column 3 is the C&I lending growth. QE_t denotes the triple of QE dummy variables. Bank controls include: size, MBS over assets, Treasuries over assets and capital over assets. See Table 2 for variable description. Regressions use bank FE as specified. Standard errors are robust and reported in brackets. ***,**,* denotes significance at the 1%, 5% and 10% level.

Table 10

Channels

	(1)	(2)	(3)	(4)
	Funding costs	Liquidity	Gains securities	Asset expansion
Treat * QE1	0.0013***	0.0008	0.0091	-0.0081***
	[0.0048]	[0.0076]	[0.0225]	[0.0030]
Treat * QE2	-0.0056	-0.0005	0.0216	-0.0089***
	[0.0038]	[0.0062]	[0.0188]	[0.0030]
Treat * QE3	-0.0022***	0.0028***	0.0308	-0.0032
	[0.0031]	[0.0074]	[0.0256]	[0.0029]
QE_t	Y	Y	Y	Y
Bank controls	Y	Y	Y	Y
Bank controls * QE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
R^2_{adj}	0.331	0.867	0.550	0.099
Observations	7,384	7,244	6,950	6,950
BHCs	351	340	340	351

This table shows the regression results of equation (4) for the period 2007Q4-2014Q1 using as dependent variable: funding costs (column 1), the amount of securities sold under agreement to repurchase over assets (column 2), amount of gains on securities over total assets (column 3) and total assets expansion (column 4). QE_t denotes the triple of QE dummy variables. Bank controls include: size, MBS over assets, Treasuries over assets and capital over assets. See Table 2 for variables description. Regressions use bank FE as specified. Standard errors are robust and reported in brackets. ***,**,* denotes significance at the 1%, 5% and 10% level

Figure 1

Figure 1A

Banks' default probabilities

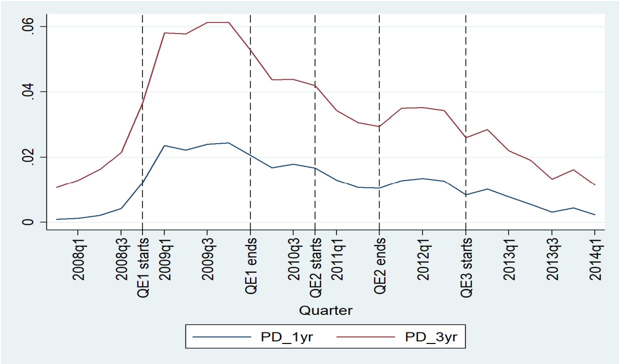
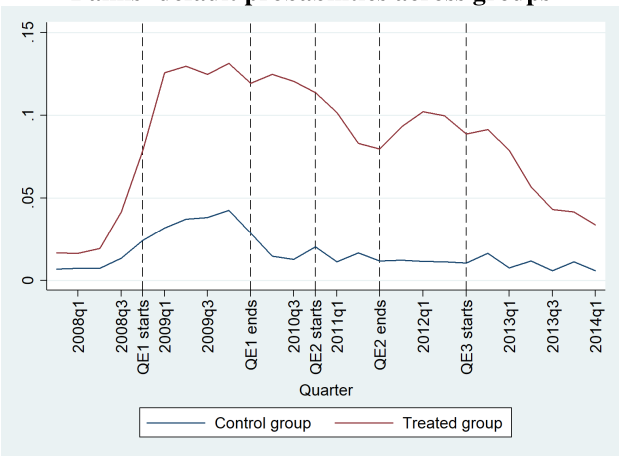


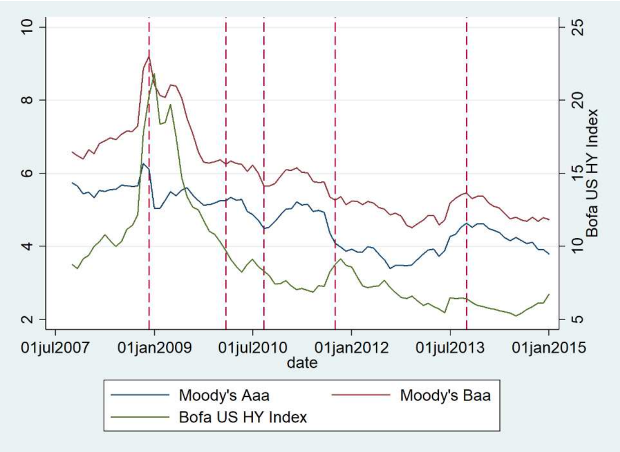
Figure 1B

Banks' default probabilities across groups



In figure 1A we plot the mean default probabilities of banks over the period 2007Q4-2014Q1. The blue line is the mean average of banks' 1-year ahead default probabilities; the red line is the mean average three years ahead default probabilities. Figure 1B plots the mean default probabilities of banks over the period 2007Q4-2014Q1 of the treated and control group. The blue line is the mean average of banks' 3-year ahead default probabilities for the control group; the red line is the mean average three years ahead default probabilities for the treated group (banks in the 75th percentile before every QE rounds). The dashed vertical lines correspond to the QE interventions.

Figure 2
Spreads in the corporate market by different ratings (Sept 2007-Jan 2015)



This figure plots the mean risk premiums in percentage of: Moody's Aaa corporate bonds (blue line), Moody's Baa corporate bonds (Baa) and the mean ICE Bofa US HY Index spread (green line) over September 2007 to January 2015 period. The dashed vertical lines correspond to the QE interventions.

Figure 3
Lending expansion across groups

Figure 3A
Total net lending expansion

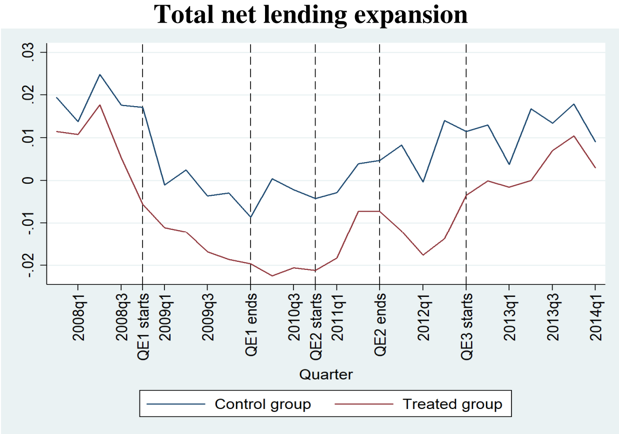


Figure 3B
RE lending expansion

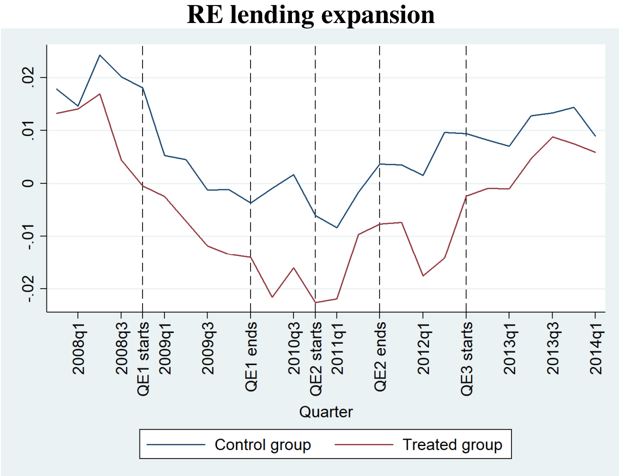
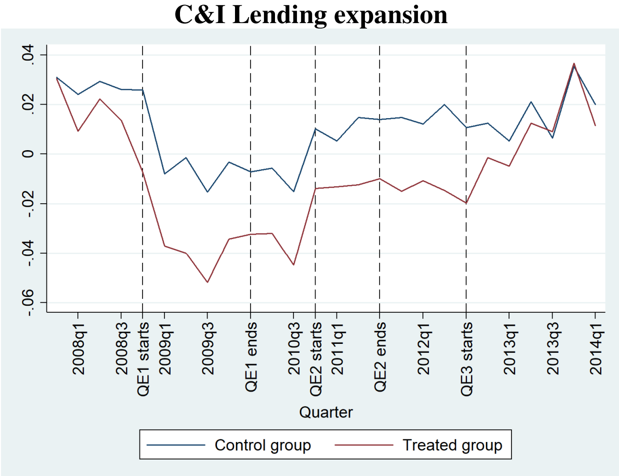


Figure 3C
C&I Lending expansion



These figures plot the total lending expansion (Figure 2A), the real estate lending expansion (Figure 2B) and the C&I lending expansion (Figure 2C) across control and treated group. The dashed vertical lines correspond to the QE interventions.

Figure 4
Coefficients estimates around QE events

Figure 4A
QE1

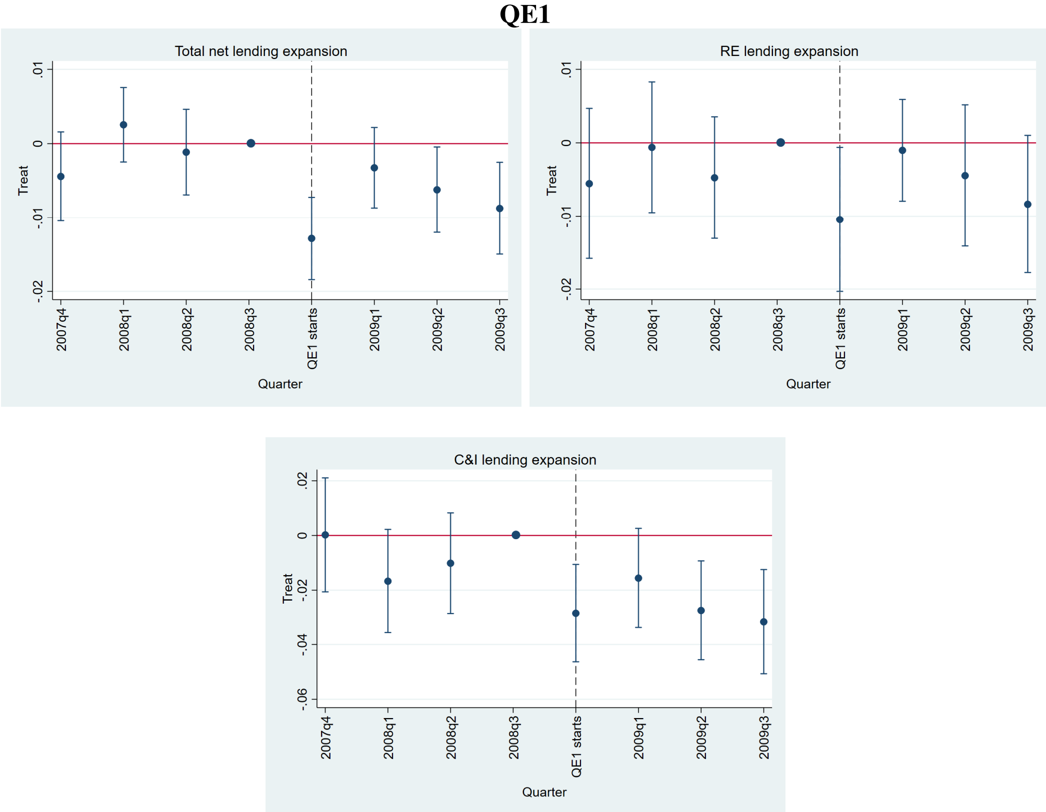


Figure 4B
QE2

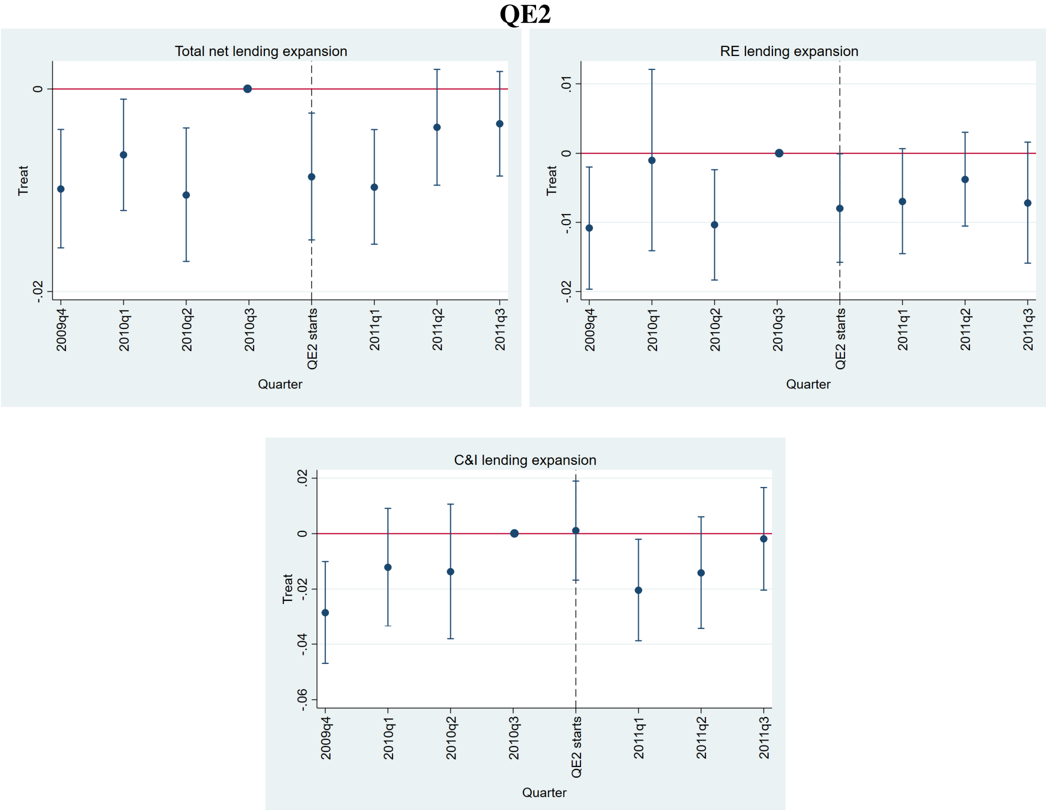
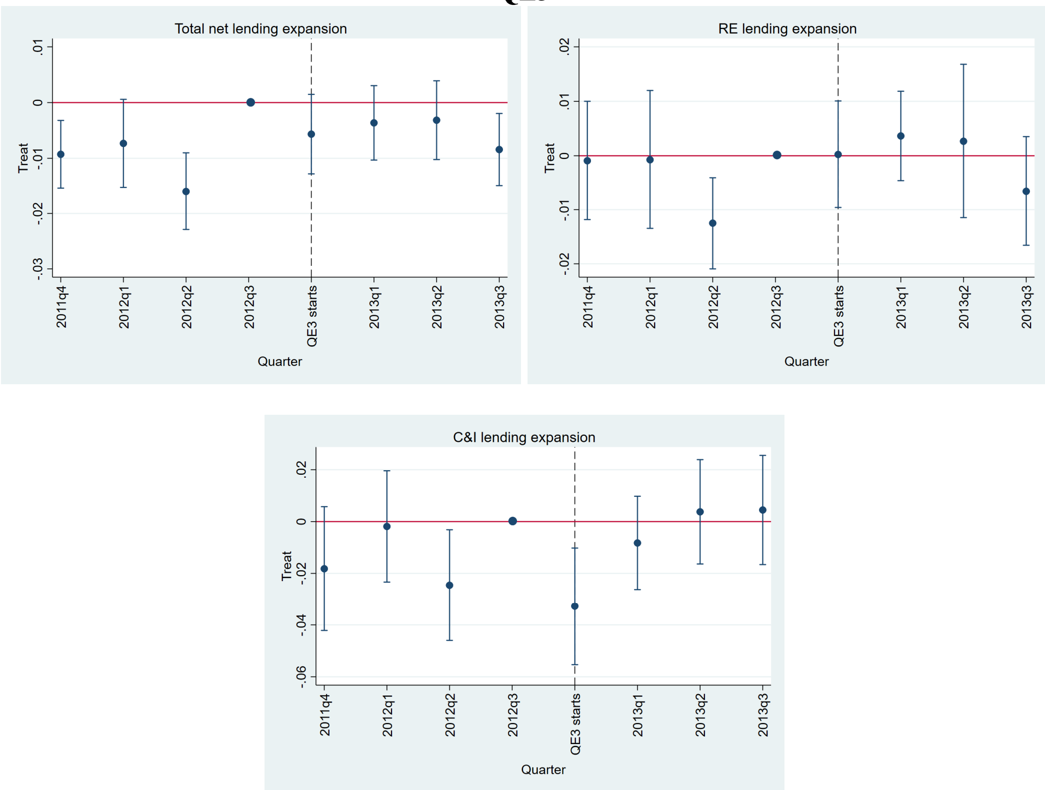
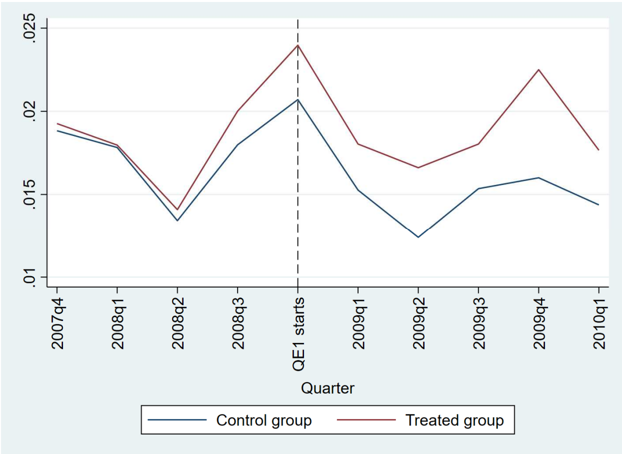


Figure 4C
QE3



These charts plot the estimated β_t coefficients of equation 5 with 95% confidence intervals around them for different lending categories around QE1 (Figure 4A), QE2 (Figure 4B) and QE3 (Figure 4C). The dashed vertical lines correspond to the QE interventions.

Figure 5
Wholesale funding costs across groups around QE1 event



This figure plots average wholesale funding costs over total assets across control and treated group. The dashed vertical line corresponds to QE1 intervention.

Figure 6
Unrealized and realized gains on securities across groups

Figure 6A
Unrealized gains on securities

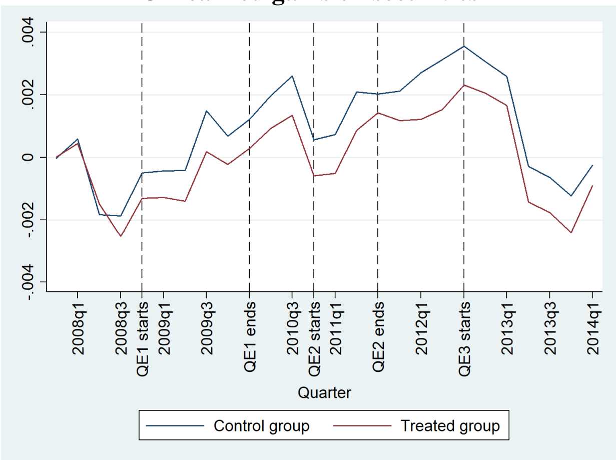
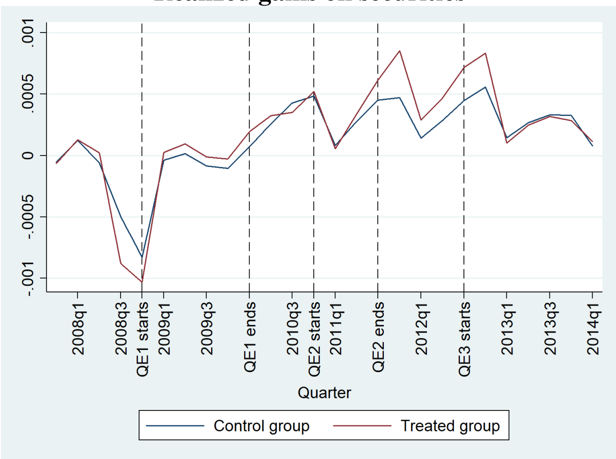


Figure 6B
Realized gains on securities



These figures plot average unrealized gains on securities over total assets (Figure 5A) and average realized gains on securities over total assets (Figure 5B) across control and treated group. The dashed vertical lines correspond to the QE interventions.

Appendix A

Methodology details on Bloomberg default probability

Bloomberg's default probability is a market-based credit risk model based on a modified Merton's (1974) option pricing model. According to Merton (1974) model, credit risk of corporate debt is a function of leverage, market capitalization and asset return volatility of the issuer. The Bloomberg default probabilities modifies the Merton model by adding information from other financial filings that improve model performance. More specifically, for the banking sector the model contains the following inputs: stock price, market capitalization, one-year stock price volatility, short-term debt, coverage ratio of non-performing assets, non-performing loans and profitability.

In comparison to non-financial firms, for banks there is a significant adjustment related to the definition of debt that has a significant impact on the estimation of the probability of default. In particular, Bloomberg's PD considers trading liabilities (repo, short sales and derivative liabilities) as important measures of credit risk alongside short-term debt. Customer deposits are not treated as debt and are viewed as a stable source of long-term funding and tend to have a lower funding cost and impact on credit risk. Finally, the model considers also the federal deposit insurance.

Other important characteristics of the Bloomberg market model are the following: 1) it is updated frequently; 2) is reliance has been extensively tested; 3) it is widely used by terminal users (mainly institutional investors) that usually combine the Merton models with credit ratings for their investment decisions.

Additional Tables

Table A.1

DiD Estimates without control variables

	(1)	(2)	(3)
	Total net lending growth	RE lending growth	C&I lending growth
Treat * QE1	-0.0131***	-0.0087***	-0.0357***
	[0.0014]	[0.0020]	[0.0045]
Treat * QE2	-0.0141***	-0.0167***	-0.0152**
	[0.0016]	[0.0019]	[0.0053]
Treat * QE3	0.0094	0.0047*	0.0096*
	[0.0017]	[0.0026]	[0.0051]
QE_t	N	N	N
Bank controls	N	N	Y
Bank controls * QE	N	N	Y
Bank FE	Y	Y	Y
R^2_{adj}	0.243	0.0212	0.094
Observations	7,005	7,296	7,284
BHCs	350	351	351

This table shows the regression results of equation (4) for the different lending categories for the period 2007Q4-2014Q1 without: QE dummies, bank controls and bank controls interacted with QE dummies. In column 1, the dependent variable is the total net lending growth, in column 2 is RE lending growth, while in column 3 is the C&I lending growth. Regressions use bank FE as specified. Standard errors are robust and reported in brackets. ***,**,* denotes significance at the 1%, 5% and 10% level.

Table A.2

DiD Estimates of table 6 with controls reported

	(1)	(2)	(3)
	Total net lending growth	RE lending growth	C&I lending growth
Treat * QE1	-0.0062***	-0.0053**	-0.0219***
	[0.0016]	[0.0025]	[0.0056]
Treat * QE2	-0.0050***	-0.0044*	-0.0097
	[0.0019]	[0.0026]	[0.0065]
Treat * QE3	-0.0018	0.0051	0.0035
	[0.0020]	[0.0031]	[0.0067]
MBS	0.0461***	0.0500**	0.1420***
	[0.0139]	[0.0205]	[0.0486]
MBS * QE1	0.0073	-0.0063	-0.0433
	[0.0133]	[0.0201]	[0.0534]
MBS* QE2	0.0237	0.0299	-0.0440
	[0.0177]	[0.0258]	[0.0677]
MBS*QE3	0.0209	0.0207	-0.0398
	[0.0146]	[0.0244]	[0.0572]
Treasuries	-0.0931	-0.0859	-0.2655
	[0.0588]	[0.0829]	[0.2274]
Treasuries * QE1	-0.0602	0.1481	0.1507
	[0.0758]	[0.1159]	[0.2762]
Treasuries * QE2	0.0291	0.0819	0.5812*
	[0.0794]	[0.1253]	[0.3137]
Treasuries * QE3	0.0204	-0.0149	0.1228
	[0.0696]	[0.0887]	[0.2619]
Size	-0.0034	0.0310***	0.0354***
	[0.0023]	[0.0049]	[0.0093]
Size * QE1	-0.0037***	-0.0006	-0.0073***
	[0.0005]	[0.0009]	[0.0017]
Size * QE2	-0.0002	-0.0004	-0.0095
	[0.0005]	[0.0008]	[0.0016]
Size * QE3	-0.0001	-0.0006	-0.0029*
	[0.0005]	[0.0007]	[0.0014]
Capital	0.0303	-0.117**	0.1195
	[0.0324]	[0.0470]	[0.1045]
Capital * QE1	0.0371	0.126**	-0.1367
	[0.0371]	[0.0470]	[0.1345]
Capital * QE2	-0.0014	0.0020	0.0562
	[0.0375]	[0.0598]	[0.1387]
Capital * QE3	0.0632*	0.1402**	0.0033
	[0.0362]	[0.059]	[0.1419]
QE_t	Y	Y	Y
Bank FE	Y	Y	Y
R^2_{adj}	0.275	0.170	0.105
Observations	7,005	7,296	7,284
BHCs	350	351	351

This table shows the regression results of equation (4) for the different lending categories for the period 2007Q4-2014Q1. In column 1, the dependent variable is the total net lending growth, in column 2 is RE lending growth, while in column 3 is the C&I lending growth. QE_t denotes the triple of QE dummy variables. Bank controls include: size, MBS over assets, Treasuries over assets and capital over assets. See Table 2 for variables description. Regressions use bank FE as specified. Standard errors are robust and reported in brackets. ***,**,* denotes significance at the 1%, 5% and 10% level.

Table A.3

Coefficients estimates of equation 5

	(1) Total net lending growth	(2) RE lending growth	(3) C&I lending growth
Panel A - Figure 4A QE1			
2007q4	-0.004 [0.003]	-0.006 [0.005]	0.001 [0.011]
2008q1	0.003 [0.003]	-0.001 [0.005]	-0.017* [0.010]
2008q2	-0.001 [0.003]	-0.005 [0.004]	-0.010 [0.009]
2008q3	Base category	Base category	Base category
2008q4	-0.013*** [0.003]	-0.010** [0.005]	-0.028*** [0.009]
2009q1	-0.003 [0.003]	-0.001 [0.004]	-0.016* [0.009]
2009q2	-0.006** [0.003]	-0.004 [0.005]	-0.027*** [0.009]
2009q3	-0.009*** [0.003]	-0.008* [0.005]	-0.032*** [0.010]
Panel A - Figure 4B QE2			
2009q4	-0.010*** [0.003]	-0.011** [0.005]	-0.028*** [0.009]
2010q1	-0.006** [0.003]	-0.001 [0.007]	-0.012 [0.011]
2010q2	-0.010*** [0.003]	-0.010** [0.004]	-0.014 [0.012]
2010q3	Base category	Base category	Base category
2010q4	-0.009***[0.003]	-0.008**[0.004]	0.001[0.009]
2011q1	-0.010*** [0.003]	-0.007* [0.004]	-0.020** [0.009]
2011q2	-0.004 [0.003]	-0.004 [0.003]	-0.014 [0.010]
2011q3	-0.003 [0.003]	-0.007* [0.004]	-0.002 [0.009]
Panel C - Figure 4C QE3			
2011q4	-0.009*** [0.003]	-0.001 [0.006]	-0.018 [0.012]
2012q1	-0.007* [0.004]	-0.001 [0.006]	-0.002 [0.011]
2012q2	-0.016*** [0.004]	-0.012*** [0.004]	-0.025** [0.011]
2012q3	Base category	Base category	Base category
2012q4	-0.006 [0.004]	0.001 [0.005]	-0.033*** [0.012]
2013q1	-0.004 [0.003]	0.004 [0.004]	-0.008 [0.009]
2012q2	-0.003 [0.004]	0.003 [0.007]	0.004 [0.010]
2012q3	-0.008** [0.003]	-0.007 [0.005]	0.004 [0.011]

This table shows the coefficients estimates of equation 5, reported in figures 4A, 4B and 4C. Standard errors are robust and reported in brackets. ***,**,* denotes significance at the 1%, 5% and 10% level.

Table A.4

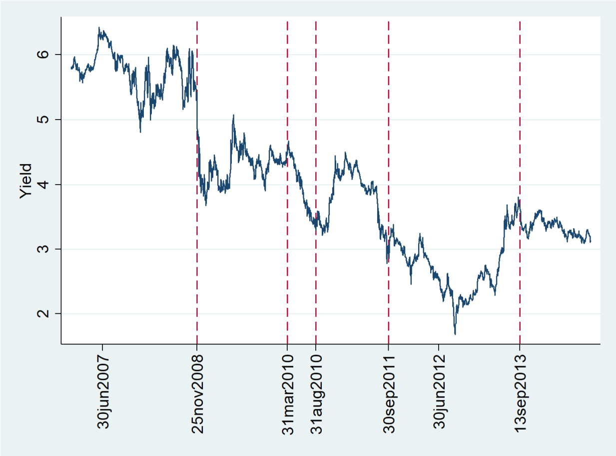
Bank balance sheet characteristics by risk quartiles

Risk quartiles over the whole sample period 2007Q4 – 2014Q1	p25	p50	p75
Capital/Assets	0.109	0.098	0.087
MBS/Assets	0.065	0.066	0.057
Treasuries/Assets	0.004	0.003	0.003
Total lending/Assets	0.653	0.658	0.683
Real Estate lending/Assets	0.489	0.499	0.532
C&I lending/Assets	0.099	0.097	0.096
Size	15.052	14.628	14.240
Retail deposits/Assets	0.683	0.663	0.649
Wholesale funding/Assets	0.180	0.207	0.231

In this table we show mean values of bank balance sheet characteristics by risk quartiles.

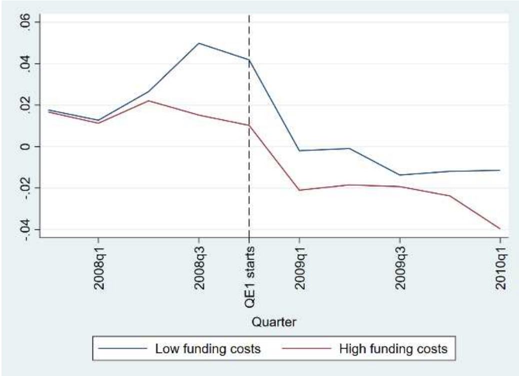
Additional Figures

Figure A.1 Fannie 30-year MBS yield



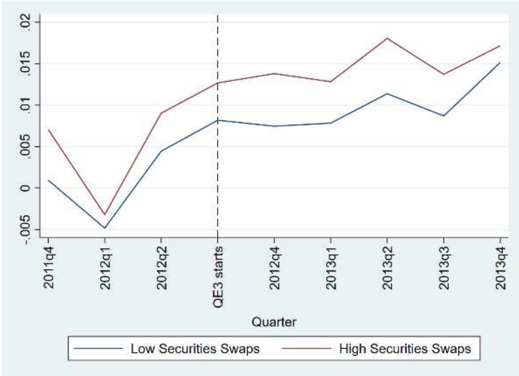
This figure shows the daily index that represents the Fannie MBS 30-year yield. The price series is from Bloomberg professional service (ticker: MTGEFNCL Index). The dashed vertical lines correspond to the QE interventions.

Figure A.2
Average funding costs and lending expansion during QE1



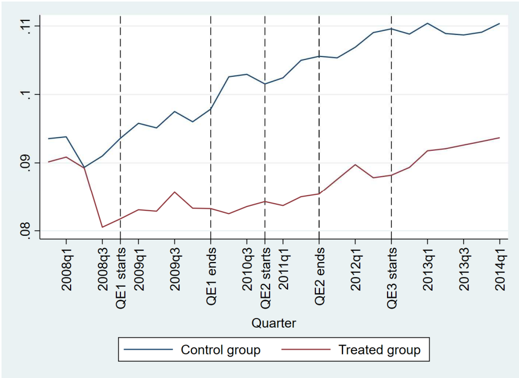
This figure shows the average lending expansion of banks with below median funding costs (low funding costs) and banks with above median funding costs (high funding costs) during QE1.

Figure A.3
Security swaps and lending expansion over QE3



This figure shows the average lending expansion of banks with below median securities swaps (low security swaps) and banks with above median securities swaps (high securities swaps) over QE3.

Figure A.4
Average capital over assets across groups



This figure shows the average ratio of total equity divided by total assets (capital/assets) across control and treated group. The dashed vertical lines correspond to the QE interventions.