The Effects of Quantitative Easing on Bank Lending Behavior*

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Abstract

Banks' exposure to large-scale asset purchases, as measured by the relative prevalence of mortgage-backed securities on their books, affects lending following unconventional monetary policy shocks. Using a difference-in-differences identification strategy, this paper finds strong effects of the third round of quantitative easing (QE3) on credit. Highly affected commercial banks increase lending by 3% relative to their counterparts. QE2 had no significant impact, consistent with its exclusive focus on Treasuries sparsely held by banks. QE1 had a significant but smaller impact on lending than QE3. Overall, banks respond heterogeneously and the type of asset being targeted is central to QE.

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1. Introduction

What are the effects of unconventional monetary policy, and how does its transmission mechanism work? These questions began to attract ever more attention during the wake of the Great Recession and following a series of aggressive liquidity measures by the Fed. In a dramatic change of policy, the European Central Bank (ECB) lately also announced its own "expanded asset purchase program". Meanwhile, banks play a central role in the monetary system and in facilitating economic activity. Shocks to the banking sector can have real effects by reducing firm borrowing and employment (Chodorow-Reich (2014b)). Motivated by these findings, this paper explores the impact of the three rounds of large-scale asset purchases (LSAPs), colloquially known as quantitative easing (QE), on commercial bank lending in the US.

The effectiveness of LSAPs has been a topic of vivid debate over the last couple of years. Most recently, when the Fed phased out of QE3, policy makers, commentators and analysts around the world were hoping to distill and summarize the policy's overall economic impact.[1] The majority of assessments, whether positive or negative, tend to focus on some uniform macroeconomic effects, including a fall in long-term interest rates, changes in confidence and inflation expectations. However, assessing policy success is made difficult by the absence of a control group which would be unaffected by the policy at such macro levels. Proponents of QE usually praise the Fed for raising asset prices and lowering yields on US Treasuries or mortgage-backed securities (MBS). Overall levels of confidence are seen to have improved, leading to greater borrowing and spending decisions on behalf of consumers. The aggregate post-crisis recovery, it is argued, came about a lot more promptly than it would have done without QE. On

[1] Source: "Has quantitative easing worked in the US?", *BBC*, Oct. 30, 2014.

the other side of the debate, skeptics see QE as having fueled asset bubbles, which led to a build-up of excessive risk-taking and encouraged investors to seek refuge in questionable investments as they increasingly chose to "reach for yield". Besides, critics have pointed to the last round of asset purchases as being inadequate and failing to raise inflation expectations. An ever improving state of the economy around 2013 was therefore seen as entirely unrelated to the Fed's last round of quantitative easing.[2]

This paper is the first to provide evidence on LSAPs stimulating lending by banks with considerable holdings of mortgage-backed securities on their books. Using a difference-in-differences identification strategy, banks with relatively larger holdings of MBS are shown to have expanded lending after the first and third rounds of quantitative easing (QE1 and QE3). On the other hand, QE2 had no significant influence on credit provision as it focused exclusively on Treasuries that are sparsely held by banks. Contrary to conventional wisdom, the novel takeaways consist in recognizing large heterogeneous effects of QE across lending institutions and the targeted asset's centrality for the transmission mechanism of unconventional monetary policy.

The paper starts out by empirically documenting commercial banks' exposure to the Fed's large-scale asset purchases of mortgage-backed securities. Aggregating individual bank data to the bank holding company (BHC) level from 2008$Q1$ until 2014$Q1$, each institution's sensitivity towards QE is captured by the MBS-to-Securities ratio in the quarter prior to any major policy introduction. Even though banks are remarkably sticky in their relative MBS holdings over time, with a probability of switching from the highest to the lowest quartile of the distribution equal to 0.55% each quarter, this measure of exposure is characterised by substantial cross-sectional variation across banks in any

[2]Source: "The 2% Mystery: Why Has QE3 Been Such a Bust?", *The Atlantic*, Feb 22, 2013.

given period: while the fraction of banks' total securities held as agency MBS is 35% on average, this number stand at 60% for the upper quartile.

Exploiting this cross-sectional variation to estimate the effect of quantitative easing via a standard difference-in-differences approach, we find strong and significant effects of QE3 on the lending behavior of bank holding companies with a large share of MBS relative to their counterparts. The former group increases levels of lending by about $2.8\% - 3.3\%$ compared to banks with little exposure. The first round, QE1, implemented during the peak of the financial crisis in 2008, had a smaller but still significant effect of $2.2\% - 2.9\%$. In contrast, QE2 focused on Treasuries and exerted virtually no differential impact on lending institutions.

Accounting for the legal restrictions governing asset purchases by the Fed as well as its declared objectives of providing support to housing markets and fostering improved financial conditions more generally, the cross-sectional variation of the MBS-to-Securities ratio across banks was orthogonal to the evolution of each institution's pre-intervention lending rates. And while the allocation of relative MBS holdings is unlikely to be random across banks, but instead reflects diverse securitization activity and specialization in real-estate lending (as confirmed by Erel et al. (2013)), the evidence is supportive of a parallel trends assumptions in lending outcomes for diverse groups of banks before the onset of QE and the resulting shocks to liquid assets. In other words, while the levels of lending are markedly different across treated and untreated banks throughout all time periods, there is no reason for the gap between both groups to have widened in the absence of the Fed's interventions. The paper also considers a myriad of robustness checks to allow for the possibility of time-varying heterogeneity across differentially exposed groups of banks. Further, extant research documents a "narrow channel" of QE, solely affecting

the prices of each particular asset being purchased and thereby lends additional support to the main identification strategy.[3] But to fully account for borrower-level shocks that could potentially confound any bank-level findings, the Call Reports are hand-matched with Dealscan loan-level data on commercial and industrial loans to estimate the effect of QE including borrower fixed effects. This setup allows to discern whether banks with larger holdings of MBS are more likely to lend to the same firm relative to other institutions and confirms the original bank-level findings.

Theoretically, there are three broad mechanisms through which large-scale asset purchases could exert influence on banks' proclivity to lend. Firstly, and according to the bank lending channel (Kashyap and Stein (1994) and Kashyap and Stein (2000)), which hinges on the failure of the Modigliani-Miller proposition for banks, QE would effectively replace securities with reserves on banks' balance sheets and thereby strengthen their ability to raise *reservable* funding, such as insured transaction deposits.[4] The second mechanism is the net-worth channel (Bernanke and Gertler (1989), Kiyotaki and Moore (1997), and Bernanke et al. (1999)). Here, unconventional monetary policy would raise the prices of MBS held as assets and lead to an improvement in the mark-to-market value of bank equity. Assuming that commercial banks target constant leverage ratios (Adrian and Shin (2010b)), these changes would induce banks to expand their lending and take on additional debt. Finally, and abstracting away from potential asset price adjustments, the "liquidity channel" of QE would consist of security purchases by the Fed from commercial banks via secondary markets and the consequent exchange of MBS for reserve

[3] Krishnamurthy and Vissing-Jorgensen (2013) argue that QE does not work via broad channels that affect the term premium on all long term bonds, but rather decrease mortgage interest rate spreads whenever targeted at MBS.

[4] Clearly, for an active lending channel to be at work banks have to encounter frictions when reducing uninsured sources of finance after adjusting for a Fed-induced increase in deposits.

balances *without* any notable modifications to the overall size of banks' balance sheets. These additional reserves could then be partially transformed into new loans and raise deposits across the banking system.

Setting out to explore which of the above theories is consonant with the data, this paper finds evidence supportive of the third "liquidity channel" during QE3 and patterns consistent with the "net-worth channel" following QE1.

1.1. Relation to the Literature

This paper is primarily related to the literature on the bank lending channel of monetary policy transmission. Seeking to find evidence that monetary policy affects the economy via credit supply, the bank lending channel posits a failure of the Modigliani-Miller theorem for banks. In line with these arguments, Kashyap and Stein (1995) show that monetary tightening reduces lending by relatively small banks. Analogously, Campello (2002) provide evidence that contractionary monetary policy reduces the amount of loans made by banks that are unrelated to a large banking group. Kashyap and Stein (2000) elucidate the same mechanisms for banks that hold fewer liquid assets, while Kishan and Opiela (2000), Gambacorta and Mistrulli (2004) carry out the analysis for banks with higher leverage ratios. More recent work investigates a risk-taking channel, where reductions in policy rates cause financial institutions to take on larger risks and result in lower risk premia (Adrian and Shin (2010a), Borio and Zhu (2012)). Focusing on the income gap, a measure of banks' cash flow exposure to interest rate risk, Landier et al. (2015) document its pivotal role for the lending behavior of banks following monetary policy shocks.

Another proximate branch of literature concerns the liability structure of banks dur-

ing periods of liquidity shocks. Dagher and Kazimov (2015) use loan-level data to show that banks end up curtailing their lending by more if they are heavily reliant on wholesale funding during crises. Ivashina and Scharfstein (2010) demonstrate that banks cut less of their lending during the 2008 crisis if they had better access to deposit financing and were less dependant on short-term debt. The broader work studying the impact of liquidity shocks on credit supply includes Puri et al. (2011), Paravisini (2008), Peek and Rosengren (2000), and Cornett et al. (2011). A recent extension of the Khwaja and Mian (2008) methodology in loan-level regressions to isolate credit supply devised by Jiménez et al. (2014) to identify aggregate firm-level effects through credit shocks is also taken up in the present study.

This research is also related to a strand of theoretical work emphasising the sharply non-linear effects of financial sector capital on risk premia and lending (He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014)). In these models, large contractions in financial sector capital lead to binding borrowing constraints or adverse feedback loops. In a fire sale, the pressure to delever decreases mark-to-market prices of assets held at other institutions, leading to further deleveraging (Shleifer and Vishny (2011)). The focus on liquidity management issues interacted with monetary policy shocks and lending choices is closely linked to the agenda of Bianchi and Bigio (2014).

Part of the mechanism uncovered in this paper is the empirical analogue of redistributive monetary policy, as first introduced by Brunnermeier and Sannikov (2015). In their model, monetary policy impacts the real economy by affecting the value of assets held by agents on their books. For instance, raising the price of a long-term security effectively improves the balance sheets of agents who hold this asset and relaxes financial constraints. In other words, such policy is equivalent to a *stealth recapitalisation* of these

agents. The key aspect is that not all agents in this economy are affected in the same way: heterogeneity in asset holdings matters for aggregate outcomes and policy makers should choose carefully which asset to buy instead of simply focusing on quantity, an insight which the present study is first to uncover empirically.

The nascent literature studying the effects of LSAPs is also very much related to this paper. The high-frequency event study by Chodorow-Reich (2014a) suggests that the Fed's unconventional monetary policy actions had a strong positive impact on banks and life insurance companies by raising the value of their legacy assets in 2008. Krishnamurthy and Vissing-Jorgensen (2013) examine the influence of quantitative easing on asset prices and interest rate spreads, Morais et al. (2015) provide some first evidence on the international dimensions of QE, documenting credit supply spillovers from US and European banks to Mexico, while a very recent paper by Di Maggio et al. (2015) looks at re-financing and consumption choices. Finally, this article is connected to previous work on the real effects of credit market disruptions, especially during the aftermath of the 2008 crisis (Chodorow-Reich (2014b) and Greenstone et al. (2014)).

2. Background of LSAPs

The initial wave of large-scale asset purchases (QE1) began on November 25, 2008 when the FOMC announced a program to purchase agency mortgage-backed securities (MBS) with the stated intentions of providing support to mortgage lending and housing markets as well as fostering improved conditions in financial markets more generally. The purchase phase was completed on March 31, 2010 after the Fed accumulated $1.25 trillion in MBS, $175 billion in federal agency debt (issued by Fannie Mae, Freddie Mac

and Ginnie Mae) and $300 billion in long-term Treasury securities. At that point, the Fed's market share of agency MBS had reached approximately 25%. While the purchase of $300 billion in long-term Treasuries was meant to exert downward pressure on interest rates in general, the joint purchase of $1.425 trillion of MBS and agency debt was aimed at increasing credit availability in private markets, resuscitate mortgage lending and supporting the housing market.

In mid-2010, numerous concerns about a deflationary spiral led to serious fears of lost decade of economic growth, similar to Japan's experience during the 1990s. To avert deflation, the Federal Open Market Committee (FOMC) introduced a second round of LSAPs (QE2), entailing the total purchase of $778 billion in long-term Treasury securities, which included $600 billion in announced program purchases and $178 billion as reinvestment of principal payments from the Fed's agency debt and MBS holdings. This second round of quantitative easing lasted from November 3, 2010 until June 30, 2011 and proceeded at a pace of $75 billion per month.

With the onset of Europe's sovereign debt crisis threatening to further destabilise the US economy, the FOMC turned to its maturity extension program, known as Operation Twist. This involved the sale of short-term Treasury securities and an equal purchase of long-term Treasury securities to exert downward pressure on long-term interest rates while maintaining the same amount of securities on the Fed balance sheet. Operation Twist was started in September 2011 and extended in June 2012 to continue through the end of 2012. Overall, the FOMC purchased, sold and redeemed $667 billion in Treasury securities through this program, dispensing all holdings of short-term securities with a maturity of one year or less.

Finally, on September 13, 2012 the FOMC began a largely unanticipated third round

of quantitative easing (QE3).[5] The purchases initially involved $40 billion in agency MBS per month. However, after Operation Twist ended in December 2012, the FOMC added $45 billion in long-term Treasury securities to the monthly purchase. And while at its December 2013 meeting, the FOMC reduced the monthly asset purchases for the first time, dropping the total amount to $75 billion from $85 billion,[6] the QE3 program continued as state-contingent and open-ended initiative until October 29, 2014 when it was formally discontinued. By the end of all there QE rounds, the Fed had accumulated $1.75 trillion in MBS, representing around 30% of the entire agency MBS market.

For the analysis in the subsequent sections, it is important to highlight some institutional features of the Fed's LSAPs throughout this period. Agency MBS securities are generally demarcated by different coupons, corresponding to the interest rate on the underlying mortgage loans. More than 90% of agency MBS trading volume occurs in the To-Be-Announced (TBA) forward market.[7] And while the degree of integration in the agency MBS market is quite high, the Fed's purchases were primarily target at mortgage-backed securities with coupons near those of *new* mortgage loan originations, often called current-coupon or production-coupon MBS. These assets have greater liquidity and are closely tied to primary mortgage rates. Meanwhile, the TBA market is the most liquid, and hence the most important secondary market for mortgage loans.

[5]The extent of the Fed's push towards recovery was a surprise to traders, prompting a rally in stocks and commodities. In particular, the Wall Street Index rose by 1.6% within two hours of the news, along with huge gains in Asian and European markets. For more: "QE3: Reactions to the Feds big stimulus move", *The Washington Post*, September 13, 2012.

[6]This $10 billion reduction consisted of an equal $5 billion decline for both MBS and US Treasury security purchases.

[7]In a TBA trade, the buyer obtains a contract for delivery of securitized mortgage loans at some date in the future. As part of a unique feature of such contracts, the buyer is left in the dark about the actual identify of the securitized mortgage loans to be delivered. Instead, participants agree on general parameters, such as the issuer, maturity, or coupon, and the buyer discovers the actual parameters of the loans 48 hours prior to the settlement of the forward contract.

Market participants that benefit from TBA trading are primarily mortgage bankers, commercial banks, and thrift institutions that originate residential mortgages and sell them into the secondary mortgage market in securitized form. According to the rules of the Federal Reserve Act, only fixed-rate agency MBS securities guaranteed by Fannie Mae, Freddie Mac and Ginnie Mae were eligible assets for purchase, including the 30-year and 15-year securities of these issuers. The New York Fed's primary dealers were entitled to transact in agency MBS directly with the Federal Reserve, and they were expected to submit bids or offers for themselves as well as for their customers.

3. Data and Empirical Strategy

3.1. Data Construction

This paper mainly relies on two datasets: i) the Consolidated Reports of Condition and Income (Call Reports), formally known as the FFIEC 031 and FFIEC 041 regulatory filings, which must be submitted each quarter by all commercial banks with insured deposits and from which all main variables in the analysis are sourced, and ii) the Dealscan syndicated loan database, which contains the borrowing history of both public and private firms that have accessed the syndicated loan market. The Call Reports include detailed information on the composition of banks' income statements, balance sheets, and off-balance sheet items. The time period under consideration in this study spans the main period of LSAPs, from 2008$Q1$ up until 2014$Q1$.

In line with most of the empirical literature based on the Call Reports, the raw data are adjusted to account for the fact that many banks are part of multibank holding companies. Hence individual bank data are aggregated to comprise holding-company

level financial information. That is, any given *bank* in the sample is really a holding company which does *not* include any of its non-bank subsidiaries, as these are excluded from the Call Reports.[8] An effort is made to minimise the number of excluded banks and thereby avoid any sample-selection biases. Following Kashyap et al. (2002), no direct conditioning on whether banks engage in mergers or acquisitions is carried out in the regression models below, even though the continuous representation of separate bank entities over the whole sample period is a binding restriction for the fixed-effects specifications in section 4.1.1.. In other words, all tests are carried out with a balanced sample of bank holding companies.[9]

The loan market data come from the Thomson Reuters Dealscan database, which collects loan-level information on syndicated loans from Securities and Exchange Commission (SEC) filings, company statements, and media reports, and attempts to process the universe of such loans.[10] The data include the identities of the borrower and lenders present at origination, the terms of the loan, the maturity, size, interest rate, type, and purpose of the loan (for example, working capital, or leveraged buyout). For the tasks in this paper, the Dealscan database is also hand-matched to the Call Reports for the 95 largest bank holding companies in the loan-level analysis of QE in section 4.1.2..

A set of dependent, independent and control variables is constructed for all included bank observations. The definition of all these variables is given precisely in Appendix A.

[8]It is important to point out that the results are largely unaffected by working with the disaggregated data at the individual bank level.

[9]As an alternative procedure to control for any possible M&A activity, restricting the entire sample to banks that have quarterly total asset growth of no more than 10% for any given banking organization yields very similar results to the ones below.

[10]Public companies are obliged to report any new bank loan to the SEC via 8-K filings, or as an attachment to their quarterly or annual reports. The public ranking of lender activity in the syndicated loan market assembled by Thomson Reuters on the basis of Dealscan is thought to provide banks with additional incentives to report loans which Dealscan might otherwise have missed. Loans with a single lead arranger and zero participants are usually somewhat larger than other loans in the dataset.

Summary statistics are reported in Tables 2 and 3.

3.2. Empirical Strategy

In light of the major LSAP events described in section 2., this paper exploits disparities in the level of exposure towards the Fed's interventions by grouping banks according to the relative amount of mortgage-backed securities on their balance sheets. For identification, this difference-in-differences (DiD) methodology relies upon the interaction of aggregate endogenous variation in MBS prices or purchases with sufficient cross-sectional variation among banks in their MBS holdings. Figure 1 plots the price series of Fannie 30–year 3% coupon MBS in Panel (a), and the prices of Fannie 30–year 5% coupon MBS in Panel (b).

[Insert Figure 1 here]

The former series is representative of the targeted securities during QE3, when interest rates were already much lower than in 2008, while the latter graph is indicative of the types of assets being purchased during the first phase of LSAPs. One immediate takeaway from Panel (b) is the relatively large and persistent price effect of QE1. In line with previous findings by Krishnamurthy and Vissing-Jorgensen (2013), the Fed programs seemed to operate via a "narrow channel", with no clear MBS price impact of QE2. The response of prices to QE3 is visible but a lot more modest than the one observed after QE1, both in terms of magnitude and life-span, which is not surprising given the substantially slower pace of MBS purchases during QE3.

It should be pointed out, however, that commercial banks held approximately $26\% - 30\%$ of total agency MBS outstanding over the period from September 2013 until December 2014,[11] and hence one should still expect a sizeable liquidity effect from the

[11] Source: Federal Reserve, Flow of Funds.

Fed's LSAPs, as will be confirmed below when looking at the effects on realized gains on available-for-sale securities for relatively exposed commercial banks.

The cross-sectional variation in MBS holdings across banks, defined by their MBS-to-Securities ratio, is also large during all periods under consideration. From the summary statistics reported in Table 2, one can see that the MBS-to-Securities ratio has a standard deviation of 0.31 and mean value of 0.35. Moreover, there are several institutions for which this variable is either zero or unity.[12] Figure 2 displays a histogram for the entire MBS-to-Securities distribution in the sample during the cutoff period before QE3, which is in 2012Q2.

[Insert Table 1, Table 2 and Figure 2 here]

In most baseline specifications, the impact of quantitative easing is assessed via difference-in-differences regressions that define banks from the *lowest* 25% of the MBS-to-Securities distribution as the control group (C) and institutions among the *highest* 25% of the sample as the treatment group (T). Moreover, as displayed in the transition matrices in Table 1, banks are extremely rigid in their relative MBS-to-Securities ranking over time, with very little movement in the re-calculated treatment assignments from quarter to quarter.

[Insert Figure 3 here]

In an initial attempt to eye-ball the main data and outcome variables, Figure 3 plots the Federal Reserve Holdings of Treasury Notes (dashed orange) and Mortgage-Backed Securities (dashed green) from 2008Q1 until 2014Q1, all measured on the right vertical axis in billions of US dollars. The figure also shows the average lending-to-assets ratios for banks within the highest 25% of MBS-to-Securities holdings (T group, in solid blue)

[12] Defining treatment by the MBS-to-Asset ratio yields very similar results.

versus the lowest 25% (C group, in solid red). The latter two ratios are measured on the left vertical axis. The shaded areas delineate the QE1, QE2 and QE3 periods.

4. Results

4.1. QE3

Starting with the most recent LSAPs and going backward in time, the analysis begins with the last wave of quantitative easing (QE3). As for any difference-in-differences estimation strategy, it is important to provide some evidence on the parallel trends assumption in the main outcome variables. That is, in the absence of treatment the unobserved disparities between both groups of banks, the treated and the control, are assumed to be constant over time. The validity of the DiD approach relies on lending *trends* that would have continued to develop as they did before the introduction of QE3 for both relatively high- and low-MBS-holding banks. Unless this assumption is valid, the estimated treatment effects would be biased versions of the true impact. For that purpose, Panel (a) of Figure 4 zooms into the main lending variable for both groups from 2011$Q1$ to 2014$Q1$, with the vertical red line demarcating the beginning of QE3.

[Insert Figure 4 here]

Clearly, while there are differences in levels across the whole time period, the divergence in trends occurs exactly around the treatment introduction in 2012$Q3$, when a precipitous fall in the average lending-to-assets ratio of the control group is observed alongside a rather moderate decline for treated banks. The difference between the two groups continues to widen further over time. Hence the graph lends support to the main

identifying assumption and validates the identification strategy. As a further robustness check, Panel (b) of Figure 4 shows the same lending-to-assets measures when the treatment and control groups are classified by the median, quartile and decile of the MBS-to-Securities distribution. Prior to the beginning of QE3, persistent and time-invariant differences in levels of lending-to-assets across these groups are observed. After the policy shock, a fanning out of diverse intensity becomes apparent, with respective groups lying up neatly between each other, as would be dictated by their relative MBS exposure. One could plausibly argue that, for example, any fundamental differences between banks assigned to the control groups defined by the median and quartiles of MBS holdings are unlikely to be substantial, except for their disparate levels of exposure toward QE. Therefore, any increasing gap between the relative lending-to-assets ratios of these groups after QE3 should be largely attributed to Fed's policy changes.

Yet even though Figures 3 and 4 contribute some preliminary evidence in favor of a positive liquidity shock stemming from the Fed's interventions, the presence of a lending channel cannot be taken for granted as banks with higher fractions of MBS holdings might differ systematically from their peers. For instance, banks with a higher exposure towards LSAPs may be lending to firms that experience faster credit demand growth due to improvements in their borrower health around the same time period. If this were true, the bank-level analysis would be spuriously driven by credit demand shocks and the results would be misattributed to the Fed's QE policies. To address these concerns, section 4.1.2. devotes attention to C&I loan issuance data from Dealscan, implementing the Khwaja and Mian (2008) (KM) within-firm estimator to absorb firm fundamental shocks that proxy for a company's level of credit demand.

[Insert Table 4 here]

Besides, Table 4 tests whether treated banks are in fact systematically different from their counterparts. As a fraction of their assets, banks with a relatively high MBS-to-Securities ratio as of 2012$Q2$ are similar to the control group in terms of their liabilities, deposits, and realised gains on securities. However, treated banks are usually a lot bigger and devote a large share of their lending to real estate. This implies that all regressions will control for size and the fraction of previous real estate exposure in a non-parametric way to capture specialization and crisis exposure during the second half of 2008. Several robustness test will further reveal that smaller banks are more responsive to QE when considered separately.

The initial regression framework to gauge the causal effects of QE consists of looking at average lending outcomes within three-quarter intervals around the policy introduction dates. The following model is estimated:

$$\log(Y_{i,t}) = \alpha + \beta Treat_i + \gamma QE_t + \delta\left(Treat_i \cdot QE_t\right) + \theta' X_{i,t} + \lambda' X_{i,t} QE_t + \nu_{i,t} \tag{1}$$

where $Y_{i,t}$ is the level of either total, real estate, or C&I lending, $Treat_i$ is an indicator variable equal to 1 whenever a bank belongs to the treatment group as defined by the upper quartile and 0 if the institution belongs to the lower quartile of the MBS-to-Securities distribution, QE_t is an indicator variable which becomes equal to 1 after the introduction of QE, and $Treat_i \cdot QE_t$ is an interaction term between the QE dummy and a bank's treatment status. Following the literature on bank lending (e.g. Kashyap and Stein (2000)), the matrix of controls, X_{it}, includes bank size, equity normalised by total assets, return on assets (ROA) as a benchmark for profitability, as well as the average exposure to real-estate lending before QE as a parsimonious way to control for special-

ization and potential crisis exposure during the early waves of LSAPs. As a further robustness check on the identification strategy, all control variables are interacted with the QE_t indicator to allow for possible heterogeneous responses to the Fed's intervention by bank holding companies of different nature. All standard errors are clustered at the bank level to allow for serial correlation across time.

[Insert Table 5 here]

The key parameter of interest is δ as it captures the difference in lending outcomes between banks with relatively high and low mortgage-backed security (MBS) portfolios after the QE3 shock. In other words, δ measures the treatment effect. Table 5 reports the results after estimating equation 1 for average lending three quarters around 2012Q3, when QE3 was introduced. Columns (1) through (4) consider total lending and report OLS as well as fixed-effects (FE) versions of the model, where columns (1) and (2) use the treatment indicator defined by the quartiles while columns (3) and (4) use the continuous MBS-to-Securities measure as of the cutoff period in 2012Q2.[13] The estimated parameter of interest, $\widehat{\delta}$, is positive and robustly statistically significant across all specifications. With the natural logarithm of lending as the dependent variable, the baseline OLS difference-in-differences estimates suggest that QE3 boosted total lending of the treated banks by about $2.8\% - 3.3\%$ relative to the control group.[14] As part of a "back-of-the-envelope" calculation, total lending by the treated banks in 2012Q2 was about \$3.4 trillion, and if one is willing to assume that the control group was completely unaffected by the policy, whereas treated banks expanded their relative lending by approximately

[13] In non-parametric versions of the model, linearity seems to be a reasonable approximation. Also, the continuous measure has the additional benefit of using all observations in the sample.

[14] The results are unaffected by replacing the dependent variable to be the logarithm of lending-to-assets, with assets held *fixed* prior to the introduction of QE. In other words, the impact of QE is large and significant because treated banks see their lending expand rather than assets contract.

3%, then the aggregate increase in bank lending would constitute about $100 billion.[15] The coefficients are slightly lower in the FE specifications, but continue to be robustly significant at the 1% level. Likewise, the estimation results are highly significant and of a similar magnitude for real estate lending in columns (5) through (8). Overall, and during times when the general level of lending continued to decrease, as implied by a negative coefficient on the QE_t dummy, the third wave of QE appears to have boosted lending undertaken by banks with high levels of exposure towards the Fed's large-scale asset purchases relative to their counterparts.

[Insert Table 6 here]

Numerous papers on the bank lending channel and transmission of monetary policy consider the *growth* rather than levels of lending as the most pertinent outcome variable. In line with this literature and as a further robustness check, the effects of QE on the differential trends in lending between the treated and control banks are explored in Table 6. Columns (1) through (6) present the results for growth in total lending as the outcome variable. In particular, the growth in total lending over six quarters before and after QE is compared. That is, lending growth from 2011Q1 through 2012Q2, versus the one from 2012Q4 until 2014Q1. Otherwise, all independent variables remain as in equation 1. The results are positive, significant and robust across various specifications with distinct controls. The growth in total lending for the treated banks appears to increase by about 2.2% relative to the growth in lending of the control group after QE3. Moreover, the results are robust to estimating WLS versions of the model in columns

[15]It should be noted, however, that these numbers are likely to represent upper bounds for the aggregate effects of QE3 on lending. In particular, the results in section 4.1.2. speak out against effects of such magnitude as the firm-level extension of the Khwaja and Mian (2008) technique for C&I loans indicates lending substitution from control to treated banks.

(1) and (3), meaning the effects are not eroded when banks are weighted in proportion to their size. The results for real estate lending in columns (7) through (12) are slightly less robust, but positive and still significant for the fixed-effects regressions. However, it seems that contrary to the levels of real estate lending, the differential trends are somewhat less affected by QE3. Overall, however, the results are largely in line with the baseline level-regressions in the remaining sections of the paper.

4.1.1. Timing of the Effects

An important concern relates to the timing of all effects documented thus far. In particular, the findings might be driven by some pre-existing trends in the data, with treated banks having begun to expand their lending relative to the control group prior to the introduction of QE3. In order to lend additional support to the causal interpretation of the results, the next series of tests relies upon using repeated obervations for the same bank holding company over time. As noted before, a balanced panel of banks is considered as a way to avoid possible M&A activity and reduce outliers. In the spirit of Granger (1969), the following fixed-effects regression allows to see whether causes happen before consequences and not the other way around:

$$\log(Y_{it}) = \alpha_i + \sum_t \gamma_t \mathbf{D}_t + \sum_t \delta_t \left(\mathbf{D}_t \cdot Treat_i\right) + X'_{it}\theta + \epsilon_{it} \tag{2}$$
$$\forall i,\ \forall t \in \{2012Q1, \ldots, 2014Q1\} \setminus \{2012Q3\}$$

where, as above, Y_{it} is the lending outcome, α_i are bank holding company fixed effects, $Treat_i$ is an indicator variable equal to 1 if a bank belongs to the upper quartile of the MBS-to-Securities distribution and 0 whenever an institution is assigned to the lower

quartile, $\mathbf{D}_t$ is an indicator for the time period (quarter), with 2012Q3 taken as the omitted category, $(\mathbf{D}_t \cdot Treat_i)$ represents an interaction term between the time indicators and a bank's MBS treatment status, and X_{it} is a matrix of control variables that includes bank size, equity normalised by total assets, and return on assets (ROA) as a benchmark for profitability. All standard errors are clustered at the bank-level to allow for serial correlation across time.

The main parameters of interest are the δ_t since they capture the difference between banks with relatively high and low mortgage-backed security holdings over time. The estimated fixed-effects model includes leads of two and lags of six quarters around the QE3 introduction date to verify the causal direction of the findings and assess if the effects grow or fade over time.

[Insert Figure 5 here]

Figure 5 plots the key estimated parameters of interest, $\widehat{\delta_t}$, with 95% confidence intervals around them. As would be consonant with a differential impact of LSAPs, the estimates in Panel (a) show no robust differences between the treated and control banks in the quarters prior to the phasing in of QE3, and sharply increasing effects on lending immediately after adoption. The results are highly significant and robust for total lending, showing a gradually increasing gap between the groups towards the the sixth quarter after the Fed's intervention date. The estimated coefficients for real estate and C&I lending in Panels (b) and (c) display similar patterns and magnitudes as the ones for total lending, with a differential impact that seems to increase over time.

[Insert Figure 6 here]

In an effort to better understand the aggregate effects of QE, the next procedure investigates whether small and large banks vary in their lending sensitivity with respect

to unconventional monetary policy. Banks that have more than $1 billion in total assets as of 2012$Q2$ are coded as "large" while institutions below this threshold are considered separately as "small". The treatment allocation by the quartiles is then re-defined within each of these balanced sub-panels. The corresponding $\widehat{\delta}_t$ parameter plots of equation 2 for small banks are displayed in Panels (a)–(c) of Figure 6; the estimates for large banks are shown in Panels (d)–(f). Clearly, the results for the former group are sizeable, statistically significant and confirm the causal interpretation of QE through their timing. However, while one may be tempted to conclude that small banks are driving all of the results, the sparseness in the number of relatively large bank holding companies should also be recognized, listing only 248 institutions in the balanced panel, as opposed to 2,412 small banks. It is well possible that a much greater sample of large banks would have rendered the results in Panels (d)–(f) significant.

[Insert Table 7 here]

One way to circumvent this problem is to consider regressions with bank observations weighted by size. This robustness check is carried out in Table 7 which shows the WLS versions of specification 1. Even though the estimates for real estate lending lose some of their significance as compared to the results before, the coefficients for total lending in columns (1) through (4) remain positive and statistically significant. In fact, using the whole sample of banks with the continuous MBS-to-Securities measure suggests a treatment effect somewhere between 3.4% and 4%. And although the cross-sectional split in Figure 6 reveals more pronounced effects for smaller banks, which is consistent with the idea of such institutions being more financially constrained, the overall effects are sizeable and significant once the whole sample of banks is used, with each company's observations weighted by its size.

4.1.2. Loan issuance

This section addresses the issue of potential confounding demand-side factors that could be driving the C&I loan result in sections 4.1. and 4.1.1.. The analytical framework employs the Khwaja and Mian (2008) (KM) technique, which has by now been widely applied in many papers to identify credit supply effects at the loan (bank-firm) level. A recent extension of this methodology devised by Jiménez et al. (2014) to analyse aggregate firm-level credit supply implications is also put to use below. In particular, the otherwise unobservable covariance between bank-specific (credit supply) shocks and firm-specific (credit demand) shocks is employed to construct an unbiased estimate of the aggregate firm-level impact of the bank lending channel that directly takes into account firm-level equilibrium adjustments.

The sample consists of American non-financial firms that receive a loan to finance the firm's operations.[16] To quantify the effect of the QE shock on firm borrowing, the methodology compares the last loan received by the firm before QE with the first loan received after QE. For QE3, the pre-QE period spans July 2010 to September 2012, while the post-QE period encompasses October 2012 to December 2013. Dealscan has information on the total dollar amount of each loan for the entire syndicate of lenders, and the size of the loan of each lender is recovered via their loan shares. These loan shares are computed following the imputation method introduced in Chodorow-Reich (2014b). For robustness, the effect of QE on a "loan renewal" dummy, equal to 1 if the firm borrows again from a given lender after QE, is also studied. This second measure of lending is robust to potential measurement errors in the dollar amount of lending.

Starting with the bank-firm level analysis and focusing on the sample of borrowers

[16]The purpose of the loan is recorded in Dealscan as either "working capital" or "corporate purposes".

that obtained a loan in pre-QE3 period can help address whether unobserved characteristics of borrowers, especially demand shocks, correlate at the lender level. The exercise begins by asking whether banks that increased overall C&I lending by more than other lenders also experienced a relative increase in their lending to the same firm when compared with other banks. Columns (1) through (6) of Table 8 implement this test by regressing the change in lending in a firm-bank pair on the QE3 exposure indicator and a full set of firm fixed-effect that absorb any borrower characteristics that could influence loan outcomes. The inclusion of borrower fixed-effects necessitates that every borrower has more than one lender. As a result, the sample includes one observation for each lead lender and participant in the pre-QE3 syndicate. The following model is estimated:

$$\log\left(1 + L^{b,f}_{post\text{-}QE3}\right) - \log\left(L^{b,f}_{pre\text{-}QE3}\right) = \eta_f + \rho \cdot Treat_b + \nu_{b,f} \tag{3}$$

where the dependent variable is the log change in the dollar value of lending by a syndicate member from the pre- to the post-QE3 period. $L^{b,f}_t$ is the dollar value of a loan multiplied by bank b's imputed share of the loan to firm f in period $t \in \{pre\text{-}QE3, post\text{-}QE3\}$, η_f are firm fixed-effects, $Treat_b$ denotes the MBS treatment indicator, and $\nu_{b,f}$ is an idiosyncratic error term.

[Insert Table 8 here]

Columns (1) and (2) of Table 8 report the results when the treatment is defined by the median of MBS-to-Securities holdings, columns (3) and (4) implement the exercise using quartiles, while columns (5) and (6) consider deciles. The positive and highly significant estimates of the main parameter of interest, ρ, indicate that firms with both treated and untreated banks in its pre-QE3 syndicate borrowed more from the treated institutions

after QE3. Looking at column (3), one can see that while overall C&I lending contracted substantially over the relevant period, banks assigned to the upper quartile of the MBS-to-Securities distribution expanded their lending by around 4.5% relative to the control group. Columns (2), (4) and (6) show that these results also hold when using the loan renewal dummy as an outcome variable.

And while $\widehat{\rho}_{FE}$ provides an unbiased estimate of the "loan bank lending channel", it does not provide a complete picture of the net firm-level effect on the economy. More precisely, the results so far are silent about potential substitution effects, whereby individual firms that borrow more from treated banks (as documented by the positive ρ in equation 3) do so because they are trying to compensate for any loss of credit induced by the control banks. Alternatively, firms may simply choose to switch to funding sources that benefit from a positive liquidity or credit supply shock, cutting their borrowing from untreated banks voluntarily. Following the extended KM procedure from Jiménez et al. (2014), the aggregate firm-level effects of QE3 are traced out by estimating a firm-level version of equation 3 where the dependent variable now measures the log change in credit for firm f stemming from *all* banks, and the treatment indicator captures the firm's average initial exposure to QE3:[17]

$$\log\left(1 + L^{f}_{post\text{-}QE3}\right) - \log\left(L^{f}_{pre\text{-}QE3}\right) = \eta_f + \overline{\rho} \cdot \overline{Treat}_f + \nu_f \tag{4}$$

The aggregate impact of the credit supply channel is captured by the parameter $\overline{\rho}$, the firm-level aggregate lending channel. If the firm does not adjust its overall level of borrowing in the face of bank-specific credit channel shocks, then $\overline{\rho}$ should equal ρ. On

[17]The results are invariant to considering a firm as treated whenever it borrows from at least one or multiple treated banks in its syndicate.

the other hand, the QE3 shock, $\overline{Treat}_f$, should not be binding for a company whenever it can perfectly adjust its sources of funding, and thus $\overline{\rho}$ would equal zero. A consistent estimate of $\overline{\rho}$ can be obtained from:

$$\widehat{\overline{\rho}} = \widehat{\overline{\rho}}_{OLS} - (\widehat{\rho}_{OLS} - \widehat{\rho}_{FE}) \cdot \frac{\mathbb{V}\text{ar}[Treat_b]}{\mathbb{V}\text{ar}[\overline{Treat}_f]} \tag{5}$$

where the second term on the right hand side of equation 5 is an adjustment term that corrects for any bias in the OLS estimate of specification 4 resulting from the unobserved covariance between bank credit supply and firm demand shocks, and the variances of bank QE3 shocks, $\mathbb{V}\text{ar}[Treat_b]$ and $\mathbb{V}\text{ar}[\overline{Treat}_f]$, are estimated directly from the data. Columns (7) and (8) of Table 8 report the OLS loan-level results, while OLS firm-level regressions yield insignificant coefficients and consequently the correction in equation 5 produces effects that are indistinguishable from zero.

To summarize, while the robustly significant estimates from columns (1)–(6) indicate that QE3 boosted lending from the treated banks, the aggregate firm-level effects do not point to a large economy-wide credit expansion. Even though C&I lending accounts for a relatively small portion of total bank credit, this firm-level evidence might point to a certain amount of substitution from the treated to the relatively unexposed banks, whereby corporates obtain a larger fraction of their financing from treated banks without increasing their overall net borrowing.

4.2. QE2

This section moves on to consider to the second round of LSAPs. In particular, the QE2 purchases were initiated by the FOMC on Novembers 3, 2010 in an effort to stimulate

the economy and prevent deflation. As described in section 2., the program resulted in total purchases of $778 billion in long-term Treasury securities by June 30, 2011. Importantly, the pace of these interventions stood at $75 billion purchases each month and was therefore a lot higher than for the MBS acquisitions during QE3. If all of the previous results were driven by some general equilibrium effects, one should not expect a smaller impact on bank lending as a consequence of QE2. In fact, given the more aggressive pace of intervention, one could argue that QE2 should have had a greater influence on the lending behavior of banks.

However, US Treasuries are in general a much smaller component of commercial banks' balance sheets than mortgage-backed securities. One can see in Table 2 that the median level of Treasuries as a fraction of total securities is zero, while the median value of MBS as a share of securities is 32%. Moreover, the upper quartile of the MBS-to-Securities distribution is 60%, whereas it is still zero for the ratio of Treasuries-to-Securities. Given this importance of MBS relative to Treasuries, one should expect QE2 to have exerted a smaller influence on bank lending after all.

[Insert Tables 9 and 10 here]

To test this whether this is true, Tables 9 and 10 estimate the same baseline regression model 1, but now considers three-period average lending outcomes around the QE2 introduction quarter in 2010$Q3$, and defines the treatment variable either by the Treasuries-to-Securities ratio (Table 9) or by the fraction of MBS to Securities as above (Table 10). The results are striking and informative about the mechanism through which LSAPs affect bank lending outcomes. As expected, all of the estimated coefficients on the interaction terms measuring the differential impact of QE2 on treated banks are statistically indistinguishable from zero in columns (1) through (8) of Table 9. The same

pattern can be observed in Table 10 when treatment is defined by MBS – the estimated parameters of interest are hardly significant and zero in almost every column.

[Insert Table 11 here]

Furthermore, the same conclusions can be drawn from the loan-issuance Dealscan exercise as discussed in section 4.1.2.. More precisely, defining the pre-QE2 window from September 2008 to November 2010, and the post-QE2 period from December 2010 to January 2012, the Khwaja and Mian (2008) within-firm estimator implemented in Table 11 yields insignificant results. This is both a confirmation of the treatment intensity through MBS, as posited by the main balance-sheet adjustment channels, and also a test of some hypothetical pre-treatment trends in the loan-issuance data – since the estimated parameters of interest, $\widehat{\rho}$, are largely indistinguishable from zero, the significance of the above QE3 results cannot be explained by some spurious trend favouring the treated banks over the untreated in terms of C&I loan issuance.

These findings provide evidence on the mechanism, challenging any general equilibrium interpretation of the results that would downplay the importance of the assets being purchased as part of any unconventional monetary policy intervention. Since numerous commercial banks were heavily exposed to fluctuations in the value (and higher acquisition volumes) of agency MBS, positive liquidity and price shocks to these particular assets led to much greater balance-sheet improvements than any policy targeted at relatively sparsely held securities. In times when QE policies become a more frequent phenomenon around the world, these results should help in guiding policy makers' decision making process, by revealing that certain financial agents would be more affected by LSAPs depending on the choice of asset.

4.3. QE1

Finally, the effects on bank lending following the initial wave of LSAPs are considered in this section. The main confounding factor around the introduction of QE1 on November 25, 2008 was the staggering intensity of the global financial crisis of 2007–2008. TED spreads, capturing the difference between the interest rates on interbank loans and on short-term US government debt, which are often taken as an indicator of economy-wide credit risk, reached 4.65% on October 10, 2008, the highest levels since Black Monday in 1987.[18] Besides, Lehman's bankruptcy on September 15, 2008 led to a substantial depreciation in the price of commercial real estate, initiating a sell-off round in the commercial mortgage-backed securities (CMBS) market. Apartment-building investors were also expected to feel the strain as Lehman unloaded its debt and equity pieces of the $22 billion purchase of Archstone, the third-largest United States real estate investment trust.[19] Since banks with a large proportion of MBS were more likely to suffer from their dramatic exposure to real estate, disentangling these contractionary forces of the crisis from any positive liquidity QE shock represents a challenge.

[Insert Table 12 here]

However, regression model 1 accounts for specialization by controlling for the fraction of real estate lending prior to QE, as well as for the interaction of this variable with the QE_t dummy. And since banks with particularly sizeable engagements in real estate tended to suffer more during the crisis, this measure should soak up a lot of pertinent sensitivity to the crisis before QE1. Table 12 presents the relevant estimation results. The three-period average lending outcomes are now defined around 2008$Q4$ when the

[18]Source: Federal Reserve Bank of St. Louis.
[19]Source: "After Lehman, Banks Jettison Commercial-Property Debt", *WSJ*, Sept. 17, 2008.

policy was launched. As before, columns (1) through (4) have total lending as the outcome variable and report OLS as well as fixed-effects (FE) versions of the model. The estimated parameter of interest, $\widehat{\delta}$, is positive, significant and robust across all specifications. The baseline OLS difference-in-differences estimates suggest that QE1 enhanced total lending of the treated banks by about $2.2\% - 2.9\%$ relative to the control group. The estimates are even more significant and of a similar magnitude for real estate lending in columns (5) through (8).

[Insert Table 13 here]

The loan-issuance Dealscan evidence is presented in Table 13. The pre-QE1 window now encompasses the timespan from September 2005 to November 2008, and the post-QE2 period covers December 2008 to January 2010. Except for the columns using treatment allocations defined by deciles, when the number of observations becomes very small, the Khwaja and Mian (2008) within-firm estimator produces significant and positive results for the parameters of interest, ρ. Both the growth in relative lending by the treated banks as well as the extensive margin of loan renewal seem to be positively and significantly affected by the treatment. And even if the results are slightly less compelling than for same procedure applied to QE3, overall this is consonant with the relatively more modest influence of QE1 on bank lending than QE3.

Despite the negative effects of the mounting financial crisis and its repercussions on credit demand and real estate lending in particular, the first wave of QE appears to have provided additional impetus to lending undertaken by banks with higher levels of exposure towards the Fed's policies as measured by their larger MBS-to-Securities holdings relative to banks in the control group.

5. Mechanisms

This section tries to explore the channel through which banks are able to convert capital gains on MBS and/or any associated positive liquidity shocks to their securities into additional lending. In principle, there are three broad mechanisms that could be at work. Firstly, when prices of mortgage-backed securities increase, the fair value of banks' assets should follow suit, and without any further changes to liabilities, banks would experience an improvement in the value of their mark-to-market equity. Changes in the fair value of equity should in turn have an impact on how much future income a bank can pledge to its investors. With an increased debt capacity and a constant leverage target, this "net-worth channel" allows commercial banks to lend out more against the issuance of additional deposits. Secondly, and according to the bank lending channel hypothesis, monetary policy has direct effects on the supply of loans because banks fund themselves with liabilities that carry reserve requirements. Large-scale asset purchases from commercial banks by the Fed, whether they occur directly or through secondary markets with primary dealers as the counterparties, would increase bank reserves and allow these lending institutions to issue more reservable deposits. The higher level of reservable liabilities would then induce banks to undertake more lending, provided they cannot switch easily to alternative sources of funding. A necessary condition for this bank lending channel to be operative is therefore some friction in the market for non-reservable liabilities, which implies a failure of the Modigliani-Miller proposition for banks.[20] The third "liquidity channel" would be characterized by little MBS price appre-

[20]Otherwise, banks should never have to forgo profitable lending opportunities due to binding reserve requirements. For example, during episodes of contractionary monetary policy, banks would offset any decline in reservable deposits by costlessly switching to liabilities that carry no reserve requirement, such as certificates of deposits (CDs).

ciation, but instead the replacement of these previously illiquid securities with reserve balances and their subsequent conversion into new loans. This mechanism would imply almost no observable changes to the size of banks' balance sheets, while deposit issuance would increase across the whole banking sector, backing up new loans emanating from the treated banks.

5.1. QE3

[Insert Figure 7 here]

Panels (a) and (b) of Figure 7 display the average net realized as well as unrealized gains or losses on securities as a fraction of assets around QE3 respectively. Despite the rather muted price impact during this last round of asset purchases, the patterns in Panel (a) can be interpreted as a sing of incremental proceeds from the sales of MBS holdings by treated banks following massive liquidity shocks from the Fed. Due to the limited price impact, the unrealized gains in Panel (b) are hardly differentially affected by the interventions for the treated and control banks. Moreover, somewhere around the announcement of tapering in early 2013, when all MBS prices collapsed precipitously, both groups of banks seem to record some unrealized losses on their MBS holdings.

[Insert Tables 14, 15 and 16 here]

These tentative findings are also backed up by regression analysis. Starting with total assets, Table 14 presents estimation results for baseline specification 1 with $Size_{it}$ (natural logarithm of assets) as the dependent variable and all the same controls except for $Size_{it}$ itself replaced by $\log(Assets_{i,2011Q1})$ in columns (1)–(4). Since all of the estimated parameters of interest capturing the differential effects between the treated and control groups

are insignificant in every regression, there are hardly any signs of a balance sheet expansion as would be consistent with either the "net-worth" or "bank lending" channels during QE3. These findings are also supported by the results in columns (1)–(4) in Table 15, which estimate regression model 1 with $\log(Currency_{it})$ instead of $\log(Lending_{it})$ as the dependent variable. The results clearly indicate that treated banks experience an increase in non-interest bearing reserves relative to the control group after QE3. The estimated magnitudes are between $3.6\% - 4.6\%$ and therefore, together with the expansion of transaction deposits, roughly in the same ballpark as the increase in total lending documented in section 4.1.. Finally, the exercise is repeated with $\log(Earnings_{it})$ as the dependent variable in columns (1)–(4) of Table 16, excluding ROA_{it} from the controls. Again, there are no robust signs of positive net income changes following QE3, as would be expected in the case of major valuation improvements. Overall, the increasing reserves at treated institutions and deposit issuance across the banking system are supportive of a "liquidity channel" explanation after QE3.

5.2. QE1

Turning attention to QE1, Panels (c)–(d) of Figure 7 show some analogous graphs for realized and unrealized gains or losses on securities. Interestingly, net unrealized gains on securities in Panel (d) show traces of a much more pronounced upward trend after QE1 for the treated banks as opposed to the untreated. This is consistent with the much steeper MBS price appreciation after QE1 than following QE3. From the realized gains plot in Panel (c), it seems that treated banks suffered greater losses right before QE1, as would be consonant with their more hefty exposure towards the crisis and not just the Fed's large-scale asset purchases. The pattern is reversed exactly after the introduction

of QE1.[21] Keeping all else constant, these movements should have raised net income, further boosting retained earnings and increasing the mark-to-market value of equity for the treated banks relative to the control group. This could then be taken as a verification of the "net-worth" channel.

The evidence from the regressions in Table 14 is starkly different from QE3. As reported in columns (5)–(8), this time around the differential expansion in assets for the treated banks relative to the untreated ones is statistically significant at 1%-level for all specifications and large in magnitude. The impact of QE1 on reserve balances is also very different from QE3: as shown in Table 15, there are hardly any significant nor robust differential changes between the treatment and control groups. This seems to be consistent with the graphical evidence from before, which has *unrealized* rather than realized gains soaking up most of the response. However, one should still not expect to see large net-worth improvements unless net income is directly affected by the policy. In other words, the mechanism relies on higher capital gains on securities not being neutralized by other losses. To this end, columns (5)–(8) of Table 16 present unequivocal evidence that treated banks experienced a sizable increase in earnings right after QE1, with the differential effect roughly around 10%. Taken together, these magnitudes are indicative of substantial "net-worth" improvements at the treated banks during QE1 which would have allowed these institutions to increase their relative levels of lending as documented in section 4.3..

[21] It should be noted, that in unreported graphs there were no diverging effects after the phasing in of QE2 for both the treatment and control groups. Again, this is in line with the analysis above and supportive of the causal interpretation of the main findings.

6. Conclusion

This paper started out by documenting large cross-sectional heterogeneities in commercial banks' mortgage-backed securities holdings and their relative exposure to large-scale asset purchases. The average MBS-to-Securities ratio is 35% and the standard deviation is about 0.31 in a sample that consists of quarterly data on US commercial banks from 2008$Q1$ until 2014$Q1$, aggregated to the bank holding company level but *excluding* any non-bank subsidiaries.

The analysis shows that banks with a relatively large fraction of MBS on their balance sheet expand lending more aggressively after QE1 and QE3 when the Fed targeted those particular types of securities. Within-firm loan-level regressions further demonstrate that the results are not driven by any simultaneous demand-side shocks. The channels tend to vary depending on the magnitude of the price impact following each intervention, with substantial evidence pointing toward a "net-worth channel" around QE1 and "liquidity" effects after QE3.

Contrary to conventional wisdom, these results suggest that QE had a differential effect on various types of financial institutions in the economy rather than "raising the tide and lifting all boats" for everyone equally via general equilibrium effects. Hence the distribution of MBS holdings across agents is crucial to the understanding of the re-distributive effects and the exact transmission mechanisms of unconventional monetary policy. This paper is the first to provide direct empirical support for the importance of targeting specific assets rather than just quantity during any large-scale asset purchasing.

A Appendix: Variable Definitions

Banks are indexed with i, whereas t stands for the quarter. All mortgage-backed securities price series are sourced from Bloomberg. All bank-level variables are drawn from the Consolidated Reports of Condition and Income (FFIEC 031 and FFIEC 041 files). Note that flow variables taken from the income statement of the Call Reports are reported each quarter as "year-to-date". To transform a year-to-date variable into a quarterly one, the variable is taken as listed for the first quarter of each year, and for each subsequent quarter, $Q = \{2, 3, 4\}$, the variable is calculated as the difference between the year-to-date values between Q and $Q - 1$.

- $\left(\frac{\textbf{MBS}}{\textbf{Sec}}\right)_{\textbf{i,t}}$: [held-to-maturity amortised cost MBS Securities + available-for-sale fair value MBS Securities]/[Total held-to-maturity amortised cost Securities + available-for-sale fair value Securities].

- $\left(\frac{\textbf{TRE}}{\textbf{Sec}}\right)_{\textbf{i,t}}$: [held-to-maturity amortised cost US Treasuries + available-for-sale fair value US Treasuries]/[Total held-to-maturity amortised cost Securities + available-for-sale fair value Securities].

- $\textbf{Size}_{\textbf{i,t}}$: $\log\left(\text{Assets}_{i,t}\right)$, where Assets $= RCFD2170$ for banks with foreign offices, and $= RCON2170$ for banks without foreign offices.

- $\textbf{Equity}_{\textbf{i,t}}$: $1-$Liabilities/Assets, where Liabilities $= RCFD2948$ and Assets $= RCFD2170$ for banks with foreign offices, and $= RCON2948$ and $= RCON2170$ for banks without foreign offices.

- $\textbf{Lending}_{\textbf{i,t}}$: loans and leases, net of unearned income $= RCFD2122$ for banks with foreign offices, and $= RCON2122$ for banks without foreign offices.

- **RE Lending$_{i,t}$**: loans secured by real estate = $RCFD1410$ for banks with foreign offices, and sum of $RCONF158$, $RCONF159$, $RCON1420$, $RCON1797$, $RCON5367$, $RCONF5368$, $RCON1460$, $RCONF160$, and $RCONF161$ for banks without foreign offices.

- **C&I Lending$_{i,t}$**: commercial and industrial loans = sum of $RCFD1763$ and $RCFD1764$ for banks with foreign offices, and $RCON1766$ for banks without foreign offices.

- **Reserves$_{i,t}$**: cash and balances due from depository institutions = sum of $RCFD0081$ and $RCFD0071$ for banks with foreign offices, and sum of $RCON0081$ and $RCON0071$ for banks without foreign offices.

- **Currency$_{i,t}$**: non-interest-bearing balances and currency and coin = $RCFD0081$ for banks with foreign offices, and = $RCON0081$ for banks without foreign offices.

- **Net Income$_{i,t}$**: Net income (loss) attributable to bank = $RIAD4340$. This variable has to be converted from year-to-date to quarterly as explained above.

- **ROA$_{i,t}$**: = Net Income$_{i,t}$ / Assets$_{i,t}$

- **Realised Gains$_{i,t}$**: Realised gains (losses) on held-to-maturity securities [$RIAD3521$] + Realised gains (losses) on available-for-sale securities [$RIAD3196$]. Note that $RIAD3521$ and $RIAD3196$ have to be converted from year-to-date to quarterly as explained above.

- **Unrealised Gains$_{i,t}$**: Net unrealized gains (losses) on available-for-sale securities, = $RCFD8434$ for banks with foreign offices, and = $RCON8434$ for banks without foreign offices.

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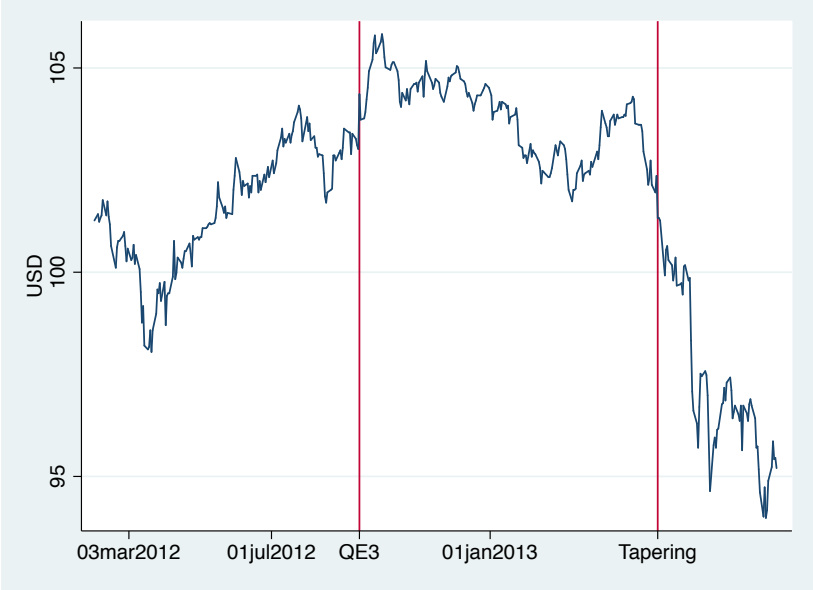
Figure 1: **MBS Prices**

(a) Fannie 30–year 3% Coupon



(b) Fannie 30–year 5% Coupon

Note: Panel (a) shows the Fannie 30-year 3% Coupon MBS price series; Panel (b) displays the Fannie 30-year 5% Coupon MBS price graph. Events related to QE1, QE2, and QE3 are delineated by vertical red lines.

Table 1: **Transition matrices**

Treatment by quartiles

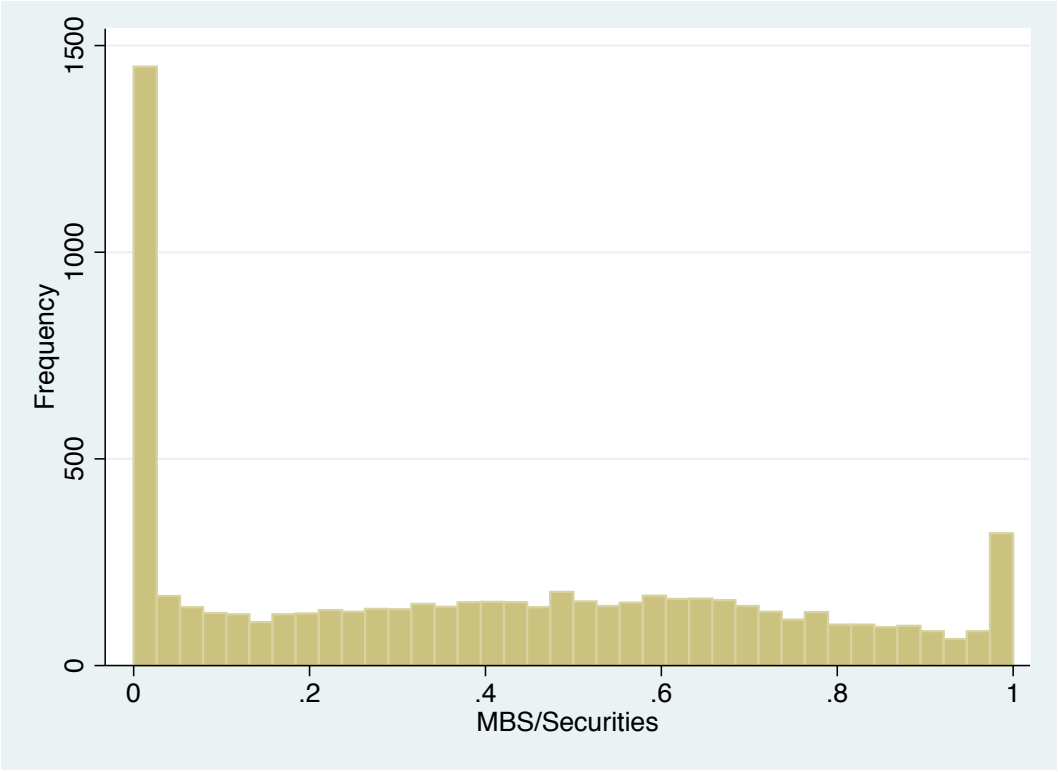
	$T_i = 0$	$T_i = 1$
$T_i = 0$	99.37	0.63
$T_i = 1$	0.55	99.45

Treatment by median

	$T_i = 0$	$T_i = 1$
$T_i = 0$	94.98	5.02
$T_i = 1$	5.05	94.95

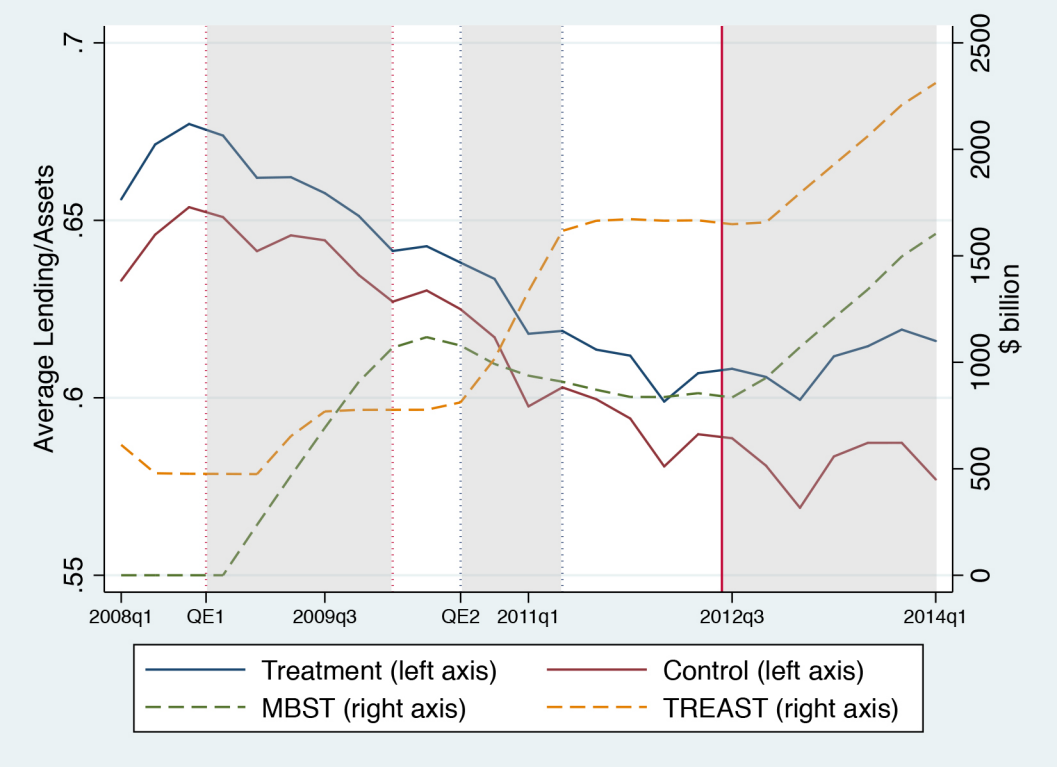
Note: These tables contain transition probabilities for being classified as belonging to the treatment group (defined either by the upper quartile or above median MBS-to-Securities holdings) between 2008Q1 *and* 2014Q1.

Figure 2: **Cross-Sectional Variation in MBS Holdings**



Note: This figure shows a snapshot of the cross-sectional variation in MBS holdings among banks in the main sample. The histogram plots frequencies for the MBS-to-Securities ratio as of 2012Q2.

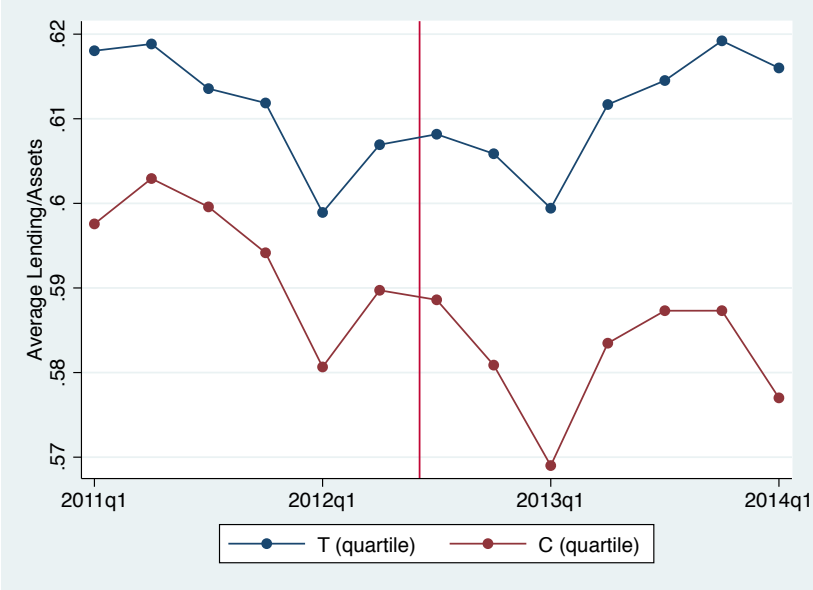
Figure 3: **Quantitative Easing & Bank Lending**



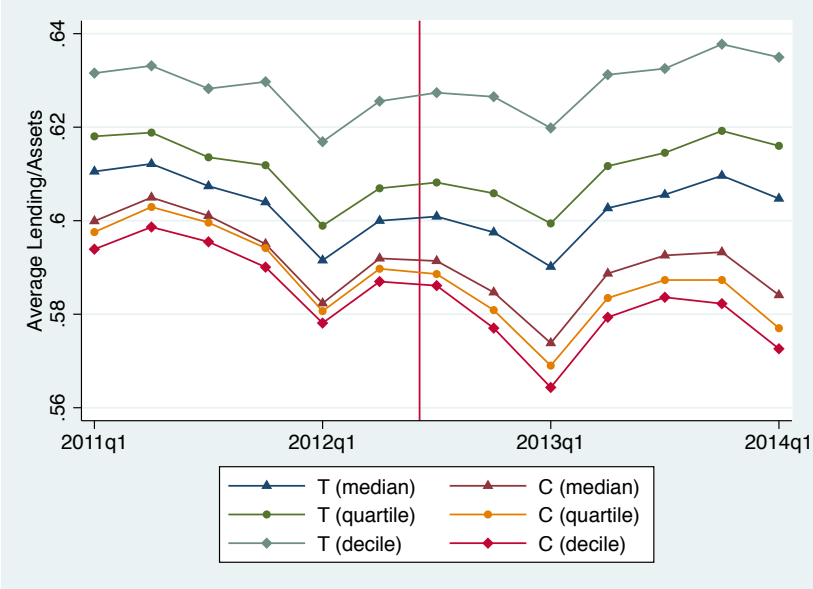
Note: This figure displays the Federal Reserve Holdings of U.S. Treasuries (orange dashed line) and Mortgage-Backed Securities (green dashed line) from 2008Q1 *until* 2014Q1*, all measured on the left vertical axis in USD millions. It also shows the average lending-to-assets ratios for banks within the highest* 25% *of MBS-to-Securities holdings (blue solid line) versus the lowest* 25% *(red solid line). The latter two ratios are measured on the right vertical axis. The shaded areas delineate the QE1, QE2 and QE3 periods.*

Figure 4: **Bank Lending**

(a) T vs. C (by quartiles)



(b) T vs. C (by median, quartiles, and deciles)



Note: These figures show the average lending-to-assets ratios for banks within the top quantiles of MBS-to-Securities holdings (T) versus the lowest quantiles during the period from 2011Q1 *until* 2014Q1.

Table 2: **Summary Statistics (Call Reports)**

Variable	mean	sd	p25	p50	p75	count
log(assets)	12.11	1.36	11.25	11.99	12.80	160606
equity / assets	0.12	0.07	0.09	0.10	0.12	160606
mbs / assets	0.08	0.10	0.00	0.05	0.12	160606
mbs / securities	0.35	0.31	0.03	0.32	0.60	157299
treasuries / securities	0.03	0.13	0.00	0.00	0.00	157299
deposits / assets	0.83	0.10	0.80	0.85	0.88	160606
reserves /assets	0.09	0.09	0.03	0.06	0.11	160606
currency / assets	0.03	0.03	0.01	0.02	0.03	160606
total lending / assets	0.62	0.17	0.53	0.65	0.74	160606
real estate lending / assets	0.45	0.18	0.33	0.47	0.59	160606
C&I lending / assets	0.09	0.07	0.04	0.07	0.11	160606
ROA	0.00	0.13	0.00	0.00	0.00	160606
realised gains / assets	0.00	0.00	0.00	0.00	0.00	160606
unrealised gains / assets	0.00	0.00	0.00	0.00	0.00	160606

Note: Summary statistics are based on the Consolidated Reports of Condition and Income between $2008Q1 - 2014Q1$ *for all US bank holding companies. All variables are quarterly.*

Table 3: **Summary Statistics (Dealscan)**

	$\Delta \log(lending)$		renewal dummy		
Sample	**mean**	**sd**	**mean**	**sd**	**count**
whole	-7.1	8.7	0.59	0.49	3267
median treatment	-5.8	8.33	0.66	0.47	2116
quartile treatment	-6.05	8.41	0.65	0.48	1328
decile treatment	-6.08	8.41	0.65	0.48	703

Note: Summary statistics are based on the Dealscan flow data.

Table 4: **Correlation between Treatment and Initial Characteristics**

	(1)		(2)		(3)	
	$Treat_i^Q$		$Treat_i^D$		$\left(\frac{MBS}{Sec}\right)_i$	
	coeff	s.e.	coeff	s.e.	coeff	s.e.
log(assets)	0.0899***	[0.006]	0.105***	[0.009]	0.0436***	[0.003]
liabilities / assets	0.714	[0.379]	-0.0559	[0.474]	0.318	[0.181]
securities / assets	0.0408	[0.157]	-0.185	[0.170]	0.143	[0.085]
deposits / assets	-0.199	[0.358]	0.292	[0.461]	-0.167	[0.164]
reserves / assets	-0.614***	[0.169]	-0.432*	[0.185]	-0.273**	[0.090]
other liabilities / assets	-0.151	[0.438]	0.149	[0.553]	-0.0355	[0.297]
other borrowed money / assets	0.820*	[0.408]	1.526**	[0.525]	0.514**	[0.187]
total lending / assets	-0.737***	[0.181]	-0.882***	[0.190]	-0.466***	[0.095]
real estate lending / assets	0.600***	[0.099]	0.536***	[0.104]	0.484***	[0.046]
C&I lending / assets	0.830***	[0.170]	0.842***	[0.197]	0.552***	[0.084]
realised gains / assets	37.51	[24.56]	49.65*	[24.04]	12.42*	[5.556]
unrealised gains / assets	8.464***	[2.464]	0.569	[2.822]	-1.847*	[0.930]
ROA	-5.225*	[2.065]	-5.038*	[2.308]	-1.865*	[0.917]
N	2834		1616		6523	
adj. R^2	0.178		0.171		0.108	

Note: This table regresses the treatment status defined by the quartile of MBS-to-Securities holdings (column 1), decile (column 2), and the continuous MBS-to-Securities measure (column 3) on various bank characteristics in $2012Q2$*, and reports the coefficient and standard errors on each variable. Standard errors are clustered at the bank-level and displayed in brackets. ***,**,* imply that coefficient estimates are statistically distinct from 0 at the 1%, 5% and 10% levels, respectively.*

Table 5: **QE3 – 3-period-averages around** 2012$Q3$

	$\log(Lending_{it})$				$\log(RE\ Lending_{it})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE_t	-0.092	-0.046	-0.086**	-0.009	-0.009	0.030	0.027	0.097
	[0.059]	[0.031]	[0.042]	[0.063]	[0.046]	[0.050]	[0.042]	[0.069]
$Treat_i$	-0.051***				0.014			
	[0.011]				[0.012]			
$Treat_i \cdot QE_t$	0.028**	0.018***			0.024***	0.024***		
	[0.013]	[0.005]			[0.006]	[0.006]		
$\left(\frac{MBS}{Sec}\right)_i$			-0.062***				0.014	
			[0.011]				[0.014]	
$\left(\frac{MBS}{Sec}\right)_i \cdot QE_t$			0.033***	0.025***			0.033***	0.031***
			[0.011]	[0.006]			[0.008]	[0.007]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls $\cdot QE_t$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	–	Yes	–	Yes	–	Yes	–
Method	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Observations	6,107	6,107	12,350	12,350	6,076	6,076	12,300	12,300
Number of banks	3,055	3,055	6,177	6,177	3,039	3,039	6,152	6,152
R^2	0.954	0.416	0.959	0.476	0.959	0.324	0.957	0.407

*Note: This table presents coefficient estimates from specifications at the bank holding company level relating average lending over three quarters before vs. after QE3 to a bank's initial exposure towards LSAPs, as captured by its treatment group membership or MBS-to-Securities ratio immediately prior to the phasing-in of QE3. The controls include Size (log total assets), equity normalized by total assets, return on assets (ROA), and average real-estate lending before QE3. All specifications include a constant and standard errors [in brackets] are clustered at the bank-level to allow for serial correlation across time. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

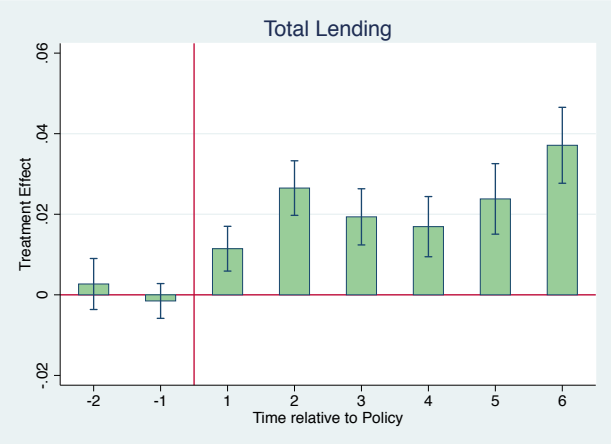
Table 6: **QE3 – lending *growth* around** 2012$Q3$

	$\mathrm{d}\log(Lending_{it})$						$\mathrm{d}\log(RE\ Lending_{it})$					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
QE_t	-0.011	-0.011*	0.074	-0.008	-0.016**	0.060	0.014	0.004	0.576**	0.016***	-0.001	0.666***
	[0.007]	[0.007]	[0.066]	[0.005]	[0.007]	[0.056]	[0.008]	[0.009]	[0.249]	[0.006]	[0.009]	[0.203]
$Treat_i$	0.001						0.022**					
	[0.008]						[0.010]					
$Treat_i \cdot QE_t$	0.022**	0.022**	0.021*				0.002	0.006	0.044*			
	[0.011]	[0.009]	[0.011]				[0.013]	[0.014]	[0.024]			
$\left(\frac{MBS}{Sec}\right)_i$				-0.002						0.027***		
				[0.008]						[0.009]		
$\left(\frac{MBS}{Sec}\right)_i \cdot QE_t$				0.024**	0.021**	0.021*				-0.006	-0.007	0.044*
				[0.011]	[0.011]	[0.011]				[0.013]	[0.016]	[0.023]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls $\cdot QE_t$	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Constant	Yes	–	–	Yes	–	–	Yes	–	–	Yes	–	–
Method	WLS	FE	FE	WLS	FE	FE	WLS	FE	FE	WLS	FE	FE
Observations	5,520	5,520	5,520	11,302	11,302	11,302	5,466	5,466	5,466	11,222	11,222	11,222
R^2	0.027	0.015	0.024	0.023	0.036	0.040	0.009	0.005	0.036	0.013	0.018	0.053
Number of banks	2,938	2,938	2,938	5,952	5,952	5,952	2,920	2,920	2,920	5,925	5,925	5,925

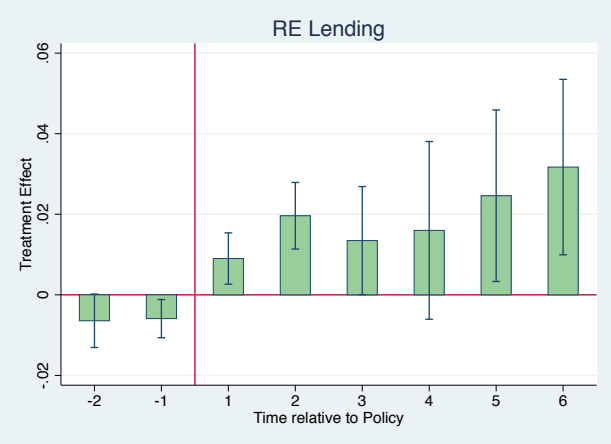
*Note: This table presents coefficient estimates from specifications at the bank holding company level relating lending growth over six quarters before vs. after QE3 to a bank's initial exposure towards LSAPs, as captured by its treatment group membership or MBS-to-Securities ratio immediately prior to the phasing-in of QE3. The controls include Size (log total assets), equity normalized by total assets, return on assets (ROA), and average real-estate lending before QE3. All specifications include a constant and standard errors [in brackets] are clustered at the bank-level to allow for serial correlation across time. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

Figure 5: **All Banks – coefficients plots**

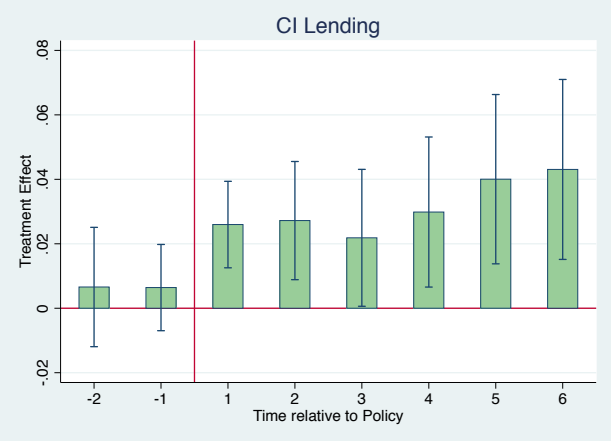
(a) Total Lending



(b) RE Lending



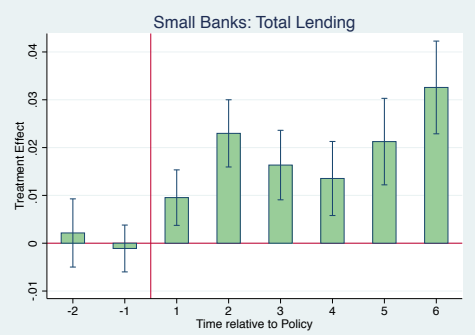
(c) C&I Lending



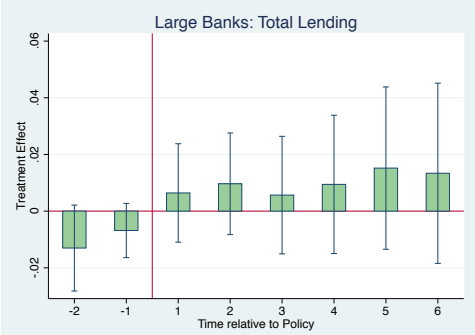
Note: These figures plot the estimated δ_t coefficients of equation 2 with 95% *confidence intervals around them. Time is measured on a quarterly level and the vertical red line delineates the beginning of QE3 in* 2012*Q*3.

Figure 6: **Small vs. Large Banks – coefficient plots**

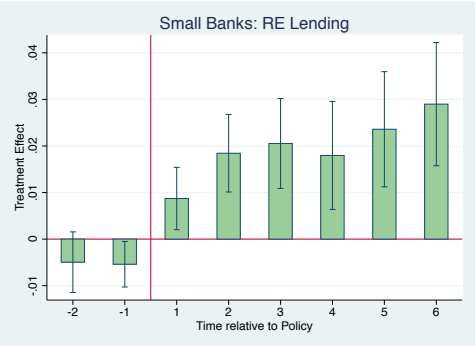
(a) Small: Total Lending



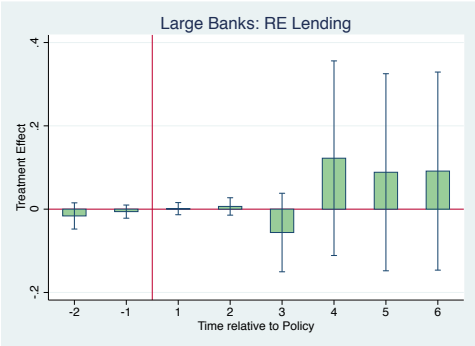
(b) Large: Total Lending



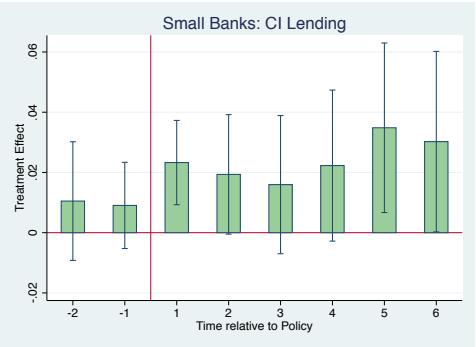
(c) Small: RE Lending



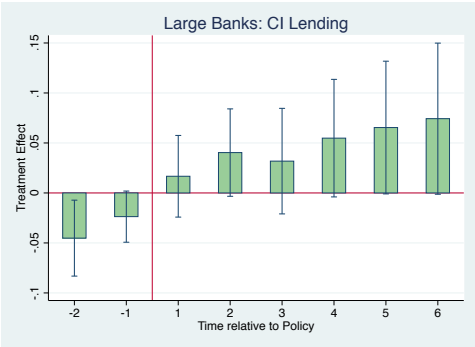
(d) Large: RE Lending



(e) Small: C&I Lending



(f) Large: C&I Lending



Note: These figures plot the estimated δ_t coefficients of equation 2 with 95% *confidence intervals around them. Time is measured on a quarterly level and the vertical red line delineates the beginning of QE3 in* 2012Q3*. Panels (a), (c), and (e) display the results for small banks; Panels (b), (d), and (f) show the coefficient plots for large banks.*

Table 7: **QE3 – WLS estimates**

	$\log(Lending_{it})$				$\log(RE\ Lending_{it})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE_t	-0.024**	-0.093	-0.026***	-0.087*	-0.012	-0.021	-0.015*	-0.004
	[0.012]	[0.078]	[0.008]	[0.051]	[0.012]	[0.080]	[0.008]	[0.058]
$Treat_i$	-0.052***	-0.050***			0.013	0.012		
	[0.013]	[0.013]			[0.012]	[0.013]		
$Treat_i \cdot QE_t$	0.034**	0.029			0.021	0.024		
	[0.017]	[0.018]			[0.017]	[0.018]		
$\left(\frac{MBS}{Sec}\right)_i$			-0.063***	-0.060***			0.009	0.007
			[0.012]	[0.012]			[0.012]	[0.012]
$\left(\frac{MBS}{Sec}\right)_i \cdot QE_t$			0.040**	0.034**			0.029*	0.032*
			[0.017]	[0.017]			[0.017]	[0.018]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Controls \cdot QE_t$	No	Yes	No	Yes	No	Yes	No	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,107	6,107	12,350	12,350	6,076	6,076	12,300	12,300
R^2	0.955	0.955	0.960	0.961	0.959	0.959	0.958	0.958

*Note: This table presents WLS coefficient estimates from specifications at the bank holding company level relating average lending over three quarters before vs. after QE3 to a bank's initial exposure towards LSAPs, as captured by its treatment group membership or MBS-to-Securities ratio immediately prior to the phasing-in of QE3. The controls include Size (log total assets), equity normalized by total assets, return on assets (ROA), and average real-estate lending before QE3. All specifications include a constant, standard errors are in brackets, and all observations are weighted by the size of a bank holding company. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

Table 8: **QE3: Khwaja-Mian technique**

	odd: $\Delta \log(loan)$; even: *renewal*							
	by median		by quartile		by decile		by median	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat_b$	2.31***	0.13***	4.49***	0.25***	3.95**	0.23**	3.15***	0.18***
	[0.77]	[0.04]	[1.49]	[0.08]	[1.80]	[0.10]	[0.70]	[0.04]
Constant	-7.99***	0.54***	-10.36***	0.40***	-9.79***	0.44***	-8.78***	0.50***
	[0.74]	[0.04]	[1.46]	[0.08]	[1.72]	[0.10]	[0.68]	[0.04]
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No
No. of firms	674	674	605	605	470	470	–	–
Observations	2116	2116	1328	1328	703	703	2116	2116
R^2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

*Note: This table presents coefficient estimates from specifications at the C&I loan-level relating changes in lending to a bank's initial exposure towards QE3. The dependent variable is either i) the log change in the dollar amount of lending by a syndicate member from the pre-(Jul. 2010 – Sept. 2012) to the post-QE3 (Oct. 2012 – Dec. 2013) period (odd columns), or ii) a loan renewal dummy (even columns). Firm fixed-effects are included in columns (1)–(6), and $Treat_b$ denotes the MBS treatment indicator. The sample includes one observation for each lead lender and participant in the pre-QE3 syndicate. Standard errors are in brackets. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

Table 9: **QE2 (treatment by Treasuries) – 3-period-averages around** 2010$Q3$

	$\log(Lending_{it})$				$\log(RE\ Lending_{it})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE_t	-0.178***	-0.128***	-0.119***	-0.114***	-0.086**	-0.095**	-0.061*	-0.074**
	[0.043]	[0.025]	[0.036]	[0.025]	[0.040]	[0.039]	[0.036]	[0.035]
$Treat_i$	0.002				-0.001			
	[0.012]				[0.013]			
$Treat_i \cdot QE_t$	0.004	0.004			-0.006	-0.004		
	[0.006]	[0.006]			[0.008]	[0.006]		
$\left(\frac{TRE}{Sec}\right)_i$			0.000				-0.101**	
			[0.041]				[0.049]	
$\left(\frac{TRE}{Sec}\right)_i \cdot QE_t$			0.015	0.018			-0.039	-0.002
			[0.015]	[0.014]			[0.048]	[0.019]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Controls \cdot QE_t$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	–	Yes	–	Yes	–	Yes	–
Method	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Observations	11,840	11,840	11,424	11,424	11,783	11,783	11,367	11,367
Number of banks	5,920	5,920	5,712	5,712	5,892	5,892	5,684	5,684
R^2	0.957	0.450	0.956	0.435	0.965	0.395	0.965	0.398

*Note: This table presents coefficient estimates from specifications at the bank holding company level relating average lending over three quarters before vs. after QE2 to a bank's initial exposure towards LSAPs, as captured by its treatment group membership or TRE-to-Securities ratio immediately prior to the phasing-in of QE2. The controls include Size (log total assets), equity normalized by total assets, return on assets (ROA), and average real-estate lending before QE2. All specifications include a constant and standard errors [in brackets] are clustered at the bank-level to allow for serial correlation across time. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

Table 10: **QE2 (treatment by MBS) – 3-period-averages around** $2010Q3$

	$\log(Lending_{it})$				$\log(RE\ Lending_{it})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE_t	-0.130***	-0.077***	-0.119***	-0.112***	-0.041	-0.051	-0.060	-0.072**
	[0.044]	[0.028]	[0.035]	[0.025]	[0.050]	[0.042]	[0.037]	[0.036]
$Treat_i$	-0.057***				0.026**			
	[0.012]				[0.013]			
$Treat_i \cdot QE_t$	0.006	0.009**			0.005	0.005		
	[0.007]	[0.004]			[0.007]	[0.007]		
$\left(\frac{MBS}{Sec}\right)_i$			-0.041***				0.004	
			[0.015]				[0.014]	
$\left(\frac{MBS}{Sec}\right)_i \cdot QE_t$			-0.002	0.004			0.012*	0.010
			[0.009]	[0.006]			[0.007]	[0.006]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Controls \cdot QE_t$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	–	Yes	–	Yes	–	Yes	–
Method	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Observations	5,854	5,854	11,424	11,424	5,817	5,817	11,367	11,367
Number of banks	2,927	2,927	5,712	5,712	2,909	2,909	5,684	5,684
R^2	0.966	0.523	0.956	0.435	0.971	0.399	0.965	0.398

*Note: This table presents coefficient estimates from specifications at the bank holding company level relating average lending over three quarters before vs. after QE2 to a bank's initial exposure towards LSAPs, as captured by its treatment group membership or MBS-to-Securities ratio immediately prior to the phasing-in of QE2. The controls include Size (log total assets), equity normalized by total assets, return on assets (ROA), and average real-estate lending before QE2. All specifications include a constant and standard errors [in brackets] are clustered at the bank-level to allow for serial correlation across time. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

Table 11: **QE2: Khwaja-Mian technique**

	odd: $\Delta \log(loan)$; even: *renewal*							
	by median		by quartile		by decile		by median	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat_b$	0.81	0.04	2.59*	0.14*	2.19	0.12	1.54**	0.82*
	[0.8]	[0.05]	[1.44]	[0.08]	[1.54]	[0.09]	[0.70]	[0.04]
Constant	-7.10***	0.59***	-8.70***	0.50***	-8.30***	0.53***	-7.77***	0.55***
	[0.77]	[0.04]	[1.41]	[0.08]	[1.48]	[0.09]	[0.74]	[0.04]
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No
No. of firms	514	514	463	463	379	379	–	–
Observations	1763	1763	1109	1109	625	625	1763	1763
R^2	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00

*Note: This table presents coefficient estimates from specifications at the C&I loan-level relating changes in lending to a bank's initial exposure towards QE2. The dependent variable is either i) the log change in the dollar amount of lending by a syndicate member from the pre-(Sept. 2008 – Nov. 2010) to the post-QE2 (Dec. 2010 – Jan. 2012) period (odd columns), or ii) a loan renewal dummy (even columns). Firm fixed-effects are included in columns (1)–(6), and $Treat_b$ denotes the MBS treatment indicator. The sample includes one observation for each lead lender and participant in the pre-QE2 syndicate. Standard errors are in brackets. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

Table 12: **QE1 – 3-period-averages around** $2008Q4$

	$\log(Lending_{it})$				$\log(RE\ Lending_{it})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE_t	0.146**	0.032	0.109***	0.009	0.094	0.024	0.102**	0.027
	[0.057]	[0.029]	[0.041]	[0.021]	[0.063]	[0.049]	[0.050]	[0.033]
$Treat_i$	-0.077***				0.025			
	[0.010]				[0.015]			
$Treat_i \cdot QE_t$	0.029*	0.016***			0.023***	0.020***		
	[0.015]	[0.006]			[0.009]	[0.008]		
$\left(\frac{MBS}{Sec}\right)_i$			-0.071***				0.009	
			[0.012]				[0.015]	
$\left(\frac{MBS}{Sec}\right)_i \cdot QE_t$			0.022*	0.016***			0.029***	0.022***
			[0.012]	[0.006]			[0.009]	[0.008]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls $\cdot QE_t$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	–	Yes	–	Yes	–	Yes	–
Method	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Observations	6,082	6,082	12,308	12,308	6,038	6,038	12,247	12,247
Number of banks	3,043	3,043	6,156	6,156	3,020	3,020	6,125	6,125
R^2	0.957	0.739	0.955	0.732	0.959	0.635	0.965	0.641

*Note: This table presents coefficient estimates from specifications at the bank holding company level relating average lending over three quarters before vs. after QE1 to a bank's initial exposure towards LSAPs, as captured by its treatment group membership or MBS-to-Securities ratio immediately prior to the phasing-in of QE1. The controls include Size (log total assets), equity normalized by total assets, return on assets (ROA), and average real-estate lending before QE1. All specifications include a constant and standard errors [in brackets] are clustered at the bank-level to allow for serial correlation across time. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

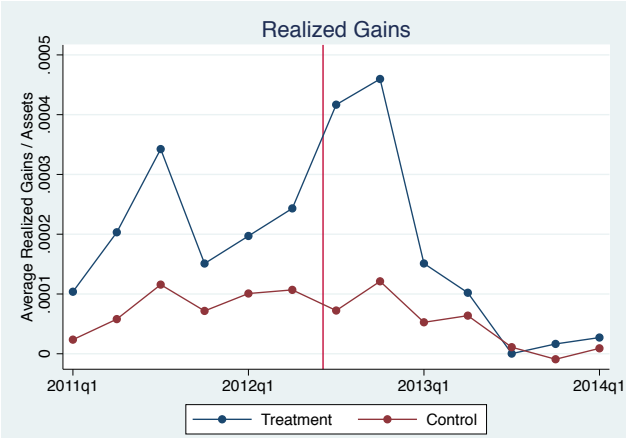
Table 13: **QE1: Khwaja-Mian technique**

	odd: $\Delta \log(loan)$; even: *renewal*							
	by median		by quartile		by decile		by median	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat_b$	1.51**	0.09**	3.20	0.19***	3.51	0.20	2.97***	0.15***
	[0.80]	[0.04]	[2.14]	[0.12]	[2.49]	[0.14]	[0.78]	[0.04]
Constant	-12.17***	31.02***	-12.26***	0.29***	-14.23***	0.18	-13.49***	0.25***
	[0.75]	[0.04]	[2.14]	[0.12]	[2.38]	[0.14]	[0.74]	[0.04]
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No
No. of firms	367	367	325	325	270	270	–	–
Observations	1384	1384	774	774	467	467	1384	1384
R^2	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01

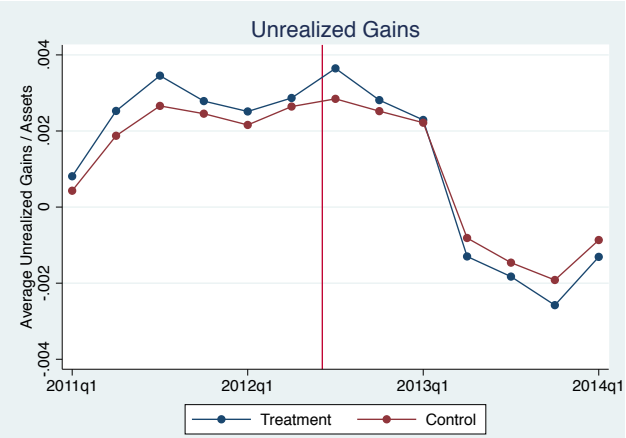
*Note: This table presents coefficient estimates from specifications at the C&I loan-level relating changes in lending to a bank's initial exposure towards QE1. The dependent variable is either i) the log change in the dollar amount of lending by a syndicate member from the pre-(Sept. 2005 – Nov. 2008) to the post-QE1 (Dec. 2008 – Jan. 2010) period (odd columns), or ii) a loan renewal dummy (even columns). Firm fixed-effects are included in columns (1)–(6), and $Treat_b$ denotes the MBS treatment indicator. The sample includes one observation for each lead lender and participant in the pre-QE1 syndicate. Standard errors are in brackets. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

Figure 7: **Mechanisms**

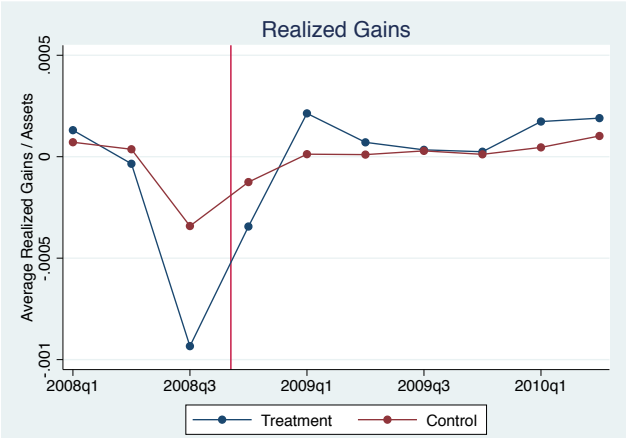
(a) QE3: Realized Gains



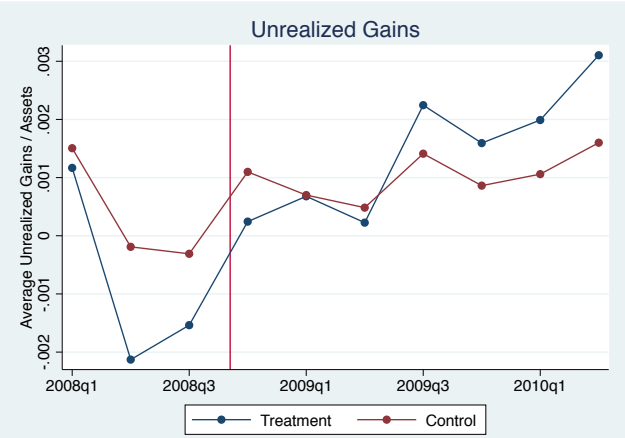
(b) QE3: Unrealized Gains



(c) QE1: Realized Gains



(d) QE1: Unrealized Gains



Note: Panels (a) and (b) display the average net realized as well as unrealized gains or losses on securities as a fraction of assets around QE3 (red vertical line), respectively. Panels (c) and (d) plot the corresponding figures around QE1.

Table 14: **Mechanisms – Effect on Assets**

	QE3: $\log(Assets_{it})$				**QE1**: $\log(Assets_{it})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE_t	0.094***	0.062***	0.101***	0.078***	0.319***	0.167***	0.277***	0.131***
	[0.017]	[0.016]	[0.017]	[0.026]	[0.041]	[0.051]	[0.030]	[0.036]
$Treat_i$	0.014**				0.017***			
	[0.007]				[0.003]			
$Treat_i \cdot QE_t$	-0.001	0.000			0.048***	0.038***		
	[0.004]	[0.004]			[0.007]	[0.006]		
$\left(\frac{MBS}{Sec}\right)_i$			0.013*				0.021***	
			[0.007]				[0.003]	
$\left(\frac{MBS}{Sec}\right)_i \cdot QE_t$			0.002	0.003			0.064***	0.048***
			[0.005]	[0.005]			[0.008]	[0.006]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Controls \cdot QE_t$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	–	Yes	–	Yes	–	Yes	–
Method	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Observations	5,408	5,408	11,140	11,140	6,046	6,046	12,238	12,238
R^2	0.984	0.206	0.984	0.182	0.987	0.353	0.987	0.378
Number of banks	2,704	2,704	5,570	5,570	3,023	3,023	6,119	6,119

Note: This table presents coefficient estimates from specifications at the bank holding company level relating average assets over three quarters before vs. after either QE1 or QE3 to a bank's initial exposure towards LSAPs, as captured by its treatment group membership or MBS-to-Securities ratio immediately prior to the phasing-in of either QE1 or QE3. The controls include Size (log total assets) as of 2011Q1 *for QE3 or as of* 2008Q1 *for QE1, equity normalized by total assets, return on assets (ROA), and average real-estate lending before either QE1 or QE3. All specifications include a constant and standard errors [in brackets] are clustered at the bank-level to allow for serial correlation across time. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

Table 15: **Mechanisms – Effect on Currency**

	QE3: $\log(Currency_{it})$				**QE1**: $\log(Currency_{it})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE_t	-0.213**	-0.129	-0.233***	-0.106	0.652***	0.671***	0.760***	0.769***
	[0.090]	[0.082]	[0.070]	[0.081]	[0.121]	[0.111]	[0.088]	[0.080]
$Treat_i$	-0.227***				-0.162***			
	[0.032]				[0.027]			
$Treat_i \cdot QE_t$	0.042**	0.045***			0.046*	0.022		
	[0.019]	[0.016]			[0.025]	[0.024]		
$\left(\frac{MBS}{Sec}\right)_i$			-0.278***				-0.222***	
			[0.036]				[0.030]	
$\left(\frac{MBS}{Sec}\right)_i \cdot QE_t$			0.037*	0.046***			0.046*	0.030
			[0.020]	[0.018]			[0.026]	[0.026]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Controls \cdot QE_t$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	–	Yes	–	Yes	–	Yes	–
Method	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Observations	6,169	6,169	12,432	12,432	6,137	6,137	12,372	12,372
R^2	0.645	0.043	0.641	0.065	0.754	0.125	0.766	0.112
Number of banks	3,085	3,085	6,217	6,217	3,070	3,070	6,188	6,188

*Note: This table presents coefficient estimates from specifications at the bank holding company level relating average non-interest bearing reserves (currency) over three quarters before vs. after either QE1 or QE3 to a bank's initial exposure towards LSAPs, as captured by its treatment group membership or MBS-to-Securities ratio immediately prior to the phasing-in of either QE1 or QE3. The controls include Size (log total assets), equity normalized by total assets, return on assets (ROA), and average real-estate lending before either QE1 or QE3. All specifications include a constant and standard errors [in brackets] are clustered at the bank-level to allow for serial correlation across time. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

Table 16: **Mechanisms – Effect on Net Income**

	QE3: $\log(Earnings_{it})$				**QE1**: $\log(Earnings_{it})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
QE_t	-0.496***	-0.289**	-0.349***	-0.220**	0.033	0.184	0.077	0.298**
	[0.136]	[0.118]	[0.098]	[0.086]	[0.180]	[0.179]	[0.139]	[0.133]
$Treat_i$	-0.269***				-0.243***			
	[0.034]				[0.040]			
$Treat_i \cdot QE_t$	0.055*	0.044			0.090**	0.079**		
	[0.033]	[0.027]			[0.044]	[0.040]		
$\left(\frac{MBS}{Sec}\right)_i$			-0.318***				-0.315***	
			[0.037]				[0.044]	
$\left(\frac{MBS}{Sec}\right)_i \cdot QE_t$			0.069*	0.049			0.128**	0.093**
			[0.036]	[0.030]			[0.051]	[0.047]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Controls \cdot QE_t$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	–	Yes	–	Yes	–	Yes	–
Method	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Observations	5,284	5,284	10,987	10,987	4,581	4,581	9,592	9,592
R^2	0.792	0.054	0.785	0.052	0.716	0.069	0.693	0.088
Number of banks	2,829	2,829	5,825	5,825	2,582	2,582	5,387	5,387

*Note: This table presents coefficient estimates from specifications at the bank holding company level relating average net income over three quarters before vs. after either QE1 or QE3 to a bank's initial exposure towards LSAPs, as captured by its treatment group membership or MBS-to-Securities ratio immediately prior to the phasing-in of either QE1 or QE3. The controls include Size (log total assets), equity normalized by total assets, and average real-estate lending before either QE1 or QE3. All specifications include a constant and standard errors [in brackets] are clustered at the bank-level to allow for serial correlation across time. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*