Unconventional Monetary Policy and the Allocation of Credit*

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Abstract

Despite massive large-scale asset purchases (LSAPs) by central banks around the world since the global financial crisis, there is a lack of empirical evidence on whether and how the composition of purchased assets matters for the pass through of unconventional monetary policy. Using rich mortgage-market data, we document that there is a "flypaper effect" of LSAPs, where the transmission of unconventional monetary policy to interest rates and (more importantly) origination volumes depends crucially on the nature of the assets purchased. For example, QE1, which involved significant purchases of GSE-guaranteed mortgages, increased GSE-guaranteed mortgage originations significantly more than the origination of non-GSE mortgages. In contrast, QE2's focus on purchasing Treasuries did not have such differential effects. Moreover, we find that most bank proceeds from LSAPs remained in Excess Reserves with the Fed, with little evidence supporting the bank-lending channel or bank-portfolio rebalancing transmission mechanism of LSAPs. The targeted nature of the Fed's RMBS purchasing program thus *de facto* allocated credit across mortgage market segments and more broadly across fixed-income markets. This led to an unintended consequence of the program: many borrowers delevered to take advantage of QE-induced low interest rates by refinancing existing mortgages into GSE-eligible loans that were below local Conforming Loan Limits and below 80% LTV. Finally, we show that HARP significantly alleviated this behavior, suggesting that complementary interventions enhanced the strength of Quantitative Easing on the real economy.

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1 Introduction

Responding to the global financial crisis, many central banks have undertaken unconventional monetary policy, primarily consisting of large-scale asset purchases (LSAPs), to stimulate their economies. While conventional monetary policy affects an economy by manipulating a single policy variable (short-term interest rates), unconventional monetary policy refers to extraordinary central bank actions such as LSAPs in response to extremal macroeconomic conditions. Since 2008, Federal Reserve LSAPs, often referred to as Quantitative Easing (QE), have changed the composition of Federal Reserve assets substantially, accompanying a five-fold increase in the the size of the Fed balance sheet (Figure 1). Despite the significance of this and similar undertakings by several other central banks, relatively little is known about whether and how LSAPs impact real economic activity or what should guide central bankers in deciding what duration, type, and amount of assets to purchase.

In this paper, we provide empirical evidence on the nature of the transmission mechanism of LSAPs, evaluating how credit was allocated and the effects of QE on bank lending and households' consumption and savings decisions. In particular, we are interested in evaluating the view that regardless of the specific long-duration asset purchased, lenders are able to rebalance their portfolios in response to lower long-term rates, spurring additional lending to households and firms. If various frictions impede perfect reallocation, then exactly how credit is allocated across borrowers and geographies and to what institutions LSAP proceeds flow becomes important. How did banks respond to capital inflows induced by QE? What is the optimal mix of assets to be purchased in a LSAP program? Are there borrowers who benefited differentially from QE and did this limit the effectiveness of LSAPs? Answers to these questions are of particular relevance given recent announcements by the European Central Bank and the central banks of China and Japan about their intent to expand LSAP programs, including expansions in the set of assets to be purchased beyond debt.[1]

Identifying the effects of aggregate policies is particularly challenging given that such policies are explicitly responding to current and anticipated aggregate shocks. For traction, much of the literature has used high-frequency asset prices in an event study framework to isolate the causal

[1]The Bank of Japan, for example, has announced its intent to purchase equities and real estate in the form of ETFs and REITs.

effect of unconventional monetary policy on the yield curve—the relationship between debt maturity and market interest rates.[2] Krishnamurthy and Vissing-Jørgensen (2011) review much of this literature and illustrate that there is important heterogeneity across asset classes in terms of which yield curves are the most affected by LSAPs. Their conclusions are consistent with the view that LSAPs bid up bond prices (pushing yields lower) by shifting outward the demand for debt, with the implication being that this movement along the supply curve should result in additional debt issuance proportional to the effect on the price of debt (interest rates). Under this transmission mechanism, whether LSAPs induce a significant change in the yield curve measures policy effectiveness.

A key virtue of using prices to quantify the effect of LSAPs is that asset prices respond immediately to central bank announcements enabling robust *ceteris paribus* analysis. However, there are reasons why focusing on prices may obfuscate the true effectiveness of LSAPs. First, because the slope of the debt supply curve is time-varying and correlated with macroeconomic conditions, the impact of LSAPs on the quantity of debt issued is a changing function of price (interest rates). Second, interest rates are observed conditional on origination; this means that inferring the effects of unconventional monetary policy from yield-curve changes will be an overstatement by assuming perfect availability of credit. The preponderance of fixed-rate mortgages in the United States means that most households need to qualify for a new refinance mortgage to benefit from monetary stimulus, excluding underwater fixed-rate borrowers (and fixed-rate borrowers who cannot qualify for new refinance mortgages) from the direct benefits of QE (see Di Maggio et al., 2014 for further discussion). Third, there are multiple channels through which prices may respond to LSAP announcements, increasing the difficulty of using price changes to learn about the transmission mechanism of unconventional monetary policy. Prices of assets not purchased by the Fed may respond either because of immediate (or anticipated slow-moving) capital reallocation or because market participants anticipate that the purchases will have stimulative effects and the resulting increase in aggregate demand will benefit non-purchased securities later. Similarly, prices may *not* respond immediately but may eventually under the segmented markets models of Greenwood and Vayanos (2013) and Greenwood et al. (2015). Finally, market price reactions in the immediate

[2]See, for example, Krishnamurty and Vissing-Jørgensen (2011, 2013), Rogers et al. (2014), and Chodorow-Reich (2014).

short-run detected using high-frequency event studies around announcements of a material departure from conventional policy may not be reflective of the eventual yields that borrowing firms or households face when eventually issuing new debt. These reasons motivate our focus on the detection of "real effects" of unconventional monetary policy—the volume market transactions induced as distinct from effects on financial variables like asset prices and interest rates.

Our identification of the effects of QE on the volume of debt issued (and not just the price) is possible thanks to the segmentation of the U.S. mortgage market and the Federal Reserve Act, which governs which assets the Fed could purchase. U.S. government intervention into the secondary mortgage market by the Government Sponsored Enterprises (GSEs) and the strict rules that govern whether a mortgage is eligible for a GSE guarantee essentially divides the primary mortgage market into "conforming" and "non-conforming" segments.[3] A key characteristic of LSAPs is that by law, the Fed can only purchase government-guaranteed debt.[4] In the context of mortgage-backed securities (MBS), this means that the Fed could only purchase Agency MBS, most of which consist of collateral guaranteed by the GSEs in the event of default and which differ from other mortgages in two key ways.[5] The outstanding balance on GSE-guaranteed mortgages must be less than so-called conforming loan limits and with limited exceptions must have loan-to-value ratios at or below 80 percent.[6] Using our comprehensive mortgage market data, we can track the effects of QE on disposition of outstanding mortgages and the origination of new mortgages, differentiating between mortgages eligible to be included in MBS sold to the Fed and otherwise. Temporal variation in the amount and type of assets purchased by each of the three QE campaigns (denoted QE1, QE2, and

[3]See Adelino et al. (2013), Best et al. (2015), and DeFusco and Paciorek (2015) for examples of papers using mortgage market segmentation for identification of the capitalization of credit access into house prices, the intertemporal substitution elasticity of mortgage borrowers, and the elasticity of mortgage demand with respect to interest rates, respectively.

[4]This fact was lamented by Bernanke (2015) while discussing QE: "Ideally we would have purchased private sector debt, like corporate bonds and private-label MBS affecting the rates on those securities directly but unlike most central banks the Fed doesn't have that authority except by invoking [section] 13(3) [of the Federal Reserve Act]."

[5]Pools of mortgages insured by the Federal Housing Authority, which constitute another segment of the mortgage market and have looser requirements on LTV and loan size, and subsequently guaranteed by Ginnie Mae were also eligible for Fed purchases. In our data, we observe that roughly 7% of QE purchases were Ginnie Mae mortgages. The term GSE refers exclusively to Fannie Mae and Freddie Mac, while Agency MBS refers to the full set of government-guaranteed MBS (the GSEs and Ginnie Mae).

[6]The GSEs will guarantee certain mortgages with above 80% LTV ratios provided they have Private Mortgage Insurance. Unfortunately, this industry was nearly wiped out by the surge in mortgage defaults during the crisis and so to first order, only mortgages with LTV ratios of 80% or lower were GSE-guaranteed during this time period. As we will show below, the Home Affordable Refinance Program (HARP) significantly relaxed the strictness of the LTV-ratio requirement for many refinance mortgages.

QE3 for short—see Figure 2), combined with markedly different macroeconomic context for each campaign, allows us to draw conclusions about the effectiveness of different types of asset purchases in varying environments and of the relative importance of stocks versus flows.

We complement this mortgage-level evidence with two additional levels of analysis. First, we use panel data on bank balance sheets and cross-sectional variation in the degree to which banks stood to benefit from QE purchases to examine how banks responded to the influx of capital from Fed LSAPs. These data allows us to trace what banks did with proceeds from asset sales to the Fed and mortgage principal prepayments induced by new originations bundled and sold to the Fed. A key institutional detail here is that although the Fed pays for its asset purchases by issuing reserves, banks are free to withdraw these reserves as currency, which they can use to lend or purchase assets. Second, we use a novel dataset linking mortgages to borrowers and their credit bureau information to track borrowers before and after they take out a new mortgage to study how households responded to the differential improvement of the GSE-eligible segment of the mortgage market, testing for behavioral changes in borrowing, saving, and durable consumption. Theoretically, refinancing can affect consumption through three different channels. First, savings from lower monthly payments result in immediately higher disposable income. Second, the present value of lower interest payments functions as a positive (albeit illiquid) wealth shock for borrowers even absent any change in monthly payments. While both these channels support increased consumption by refinancers, a third channel mitigates the strength of such a response on aggregate. When borrowers engage in cash-in refinancing by bringing cash to closing to take out a smaller loan than their previous one, this decreases their stock of liquid wealth. If QE induces such behavior, this unintended consequence of QE is likely to have a negative multiplier on economic activity as borrowers delever to qualify for GSE-eligible mortgages and take advantage of QE-induced low interest rates (see, for example, Mian and Sufi, 2014).

Consistent with existing literature, we find that interest rates decreased by around 100 basis points on average in response to the beginning of QE1. However, we show that interest rates on jumbo loans decreased significantly less, finding that there is a significant increase in the jumbo-conforming spread, a spike which is comparable in magnitude to the effect on this spread of the collapse in private securitization during the crisis.[7] We then turn to examining how QE1 affected

[7]Most jumbo loans were privately securitized before March 2007. See Fuster and Vickery (2015).

the volume of new mortgages issued. We find that financial institutions more than tripled their monthly origination of mortgages that were eligible for purchase by the Fed, while the origination of loans above the conforming loan limits increased much less dramatically, a difference that we attribute to a combination of the significantly lower rates and greater accessibility of GSE-eligible mortgage credit relative to non-conforming (i.e. non-prime and/or jumbo) credit during QE1. Next, we verify that this heterogeneity in the mortgage market response to QE1 was a function of the type of debt the central bank purchases, by contrasting the effect of various QE episodes. As shown in Figure 3 and discussed in detail in Section 2, QE1 and QE3 involved MBS and Treasury purchases, while QE2 purchases consisted exclusively of Treasuries. We show that QE MBS purchases had a relatively immediate and economically significant effect mortgage originations. QE1 in particular, which occurred at a time when the banking sector was much less healthy than in QE3, had a much stronger impact on the origination of mortgages that were eligible to be bundled into the type of MBS that the Fed was purchasing, with more modest effects on other types of mortgages and other types of debt.[8]

Turning to the heterogeneous effects of QE on household financial decision making, we provide evidence for QE-induced deleveraging. Specifically, over 40% of jumbo borrowers who refinance during QE1 take out a GSE-eligible loan, on average paying down their original mortgages by $26,000. A similar fraction of borrowers who refinance loans with current LTVs of over 80 percent engage in cash-in refinancing, on average paying down $12,000 of mortgage principal. In other words, the differential availability and price of GSE-eligible versus GSE-ineligible mortgages resulted in significant crowding-in to the GSE-eligible segment of the mortgage market by households who deleveraged to do so. Importantly, we also find that the Home Affordable Refinancing Program (HARP) alleviated this deleveraging behavior significantly by allowing high-LTV borrowers to refinance into a GSE-eligible mortgage, highlighting the complementarity between unconventional monetary policy and other interventions in the mortgage market.

Finally, to examine how banks responded to the influx of capital from Fed LSAPs, we collect

[8]One potential confounding factor is the increase in the conforming loan limit passed in February 2008: the observed increase in GSE-eligible loan origination could have been the result of the newly defined limits. To address this concern, we show that the same stark increase in mortgage origination for GSE-eligible loans is observed in low-cost areas, regions in which the conforming loan limits did not change. Our results hinge on the differential response between jumbo and non-jumbo loans as well as between QE1 and QE2, which suggests that the mortgage origination was mainly driven by the type of assets purchased by the Fed.

information on the banks' total borrowing from the liquidity facilities introduced in the aftermath of the crisis, e.g. Term Auction Facility (TAF) and Term Securities Lending Facility (TSLF). We show that banks benefiting the most from these programs increased their lending and their MBS holdings and not their cash holdings. This result suggests that these direct liquidity injections were particularly effective at easing banks' financial conditions and supporting credit markets. We then trace banks' response to QE1 by investigating how banks with larger real-estate asset holdings change their lending behavior. The fraction of real estate assets on the banks' balance sheets proxies for the cash injection these banks received resulting from the prepayment of the mortgages induced by refinance originations bundled into MBS and sold to the Fed. We find that the banks that benefited the most from QE1 purchases increased their cash holdings but did not increase their lending. As QE1 was implemented when the economic activity was extremely depressed, these results might be driven by the lack of profitable investment opportunities. To control for changes in credit demand, we complement the previous findings by matching loan-level information from the Dealscan database of syndicated loans to bank holding company information. This allows us to compare banks with different exposure to QE1, lending to the same borrower, and in the same quarter, still finding that banks benefitting the most from QE1 did not increase their lending. Event studies address concerns about correlation between the intensity of bank real-estate holdings and bank distress.

1.1 Related Literature

Growing theoretical and empirical literatures study the effects of unconventional monetary policy. Until the financial crisis, the benchmark theory for many macroeconomists has always been that non-standard open market operations in private assets are irrelevant as shown first by Wallace (1981), and extended to models with nominal frictions and money in the utility function and zero nominal interest rate by Eggertsson et al. (2003). The idea in these papers is that once the nominal interest rate reaches its lower bound, liquidity has no further role in this class of models, or in most other standard models with various types of frictions, such as Rotemberg and Woodford (1997) or Christiano et al. (2005).

However, in the aftermath of the crisis, other studies have highlighted the mechanisms through which unconventional monetary policy can have a significant impact. For instance, Woodford and

Curdia (2011) provide a model with heterogeneous agents and imperfections in private financial intermediation to provide two necessary conditions for quantitative easing to have no effect: 1) that the increase in reserves finances an increase in central-bank holdings of Treasury securities rather than an increase in central-bank lending to the private sector and 2) that the policy does not change expectations about how future interest-rate policy will be conducted. Both of these conditions are violated by QE1. Brunnermeier and Sannikov (2015) show that monetary policy can work against the adverse feedback loops that precipitate crises by affecting the prices of assets held by constrained agents and redistributing wealth. Drechsler et al. (2014) point out the role played by large-scale asset purchases, equity injections, and asset guarantees in supporting risky asset prices. Similarly, Gertler and Karadi (2011) show in the context of a DSGE model of unconventional monetary policy that during a crisis, the balance sheet constraints on private intermediaries tighten, raising the net benefits from central bank intermediation. These benefits may be substantial when the zero lower bound constraint binds. Greenwood et al. (2015) demonstrate that understanding market segmentation is important in designing and evaluating LSAPs.

Closer in spirit to our analysis is the work by DelNegro et al. (2010), who investigate the effects of interventions in which the government provides liquidity in exchange for illiquid private paper once the nominal interest rate reaches the zero bound. In their study, the source of the 2008 crisis is a shock to the liquidity of private paper (e.g. mortgage-backed securities) with secondary markets for these securities freezing. They show that unconventional monetary policy can alleviate the crisis by directly targeting the source of the problem, which is the illiquidity of private paper. By swapping illiquid private paper for liquid government debt, the Fed improves the liquidity of the aggregate portfolio holdings of the private sector, and the intervention lubricates financial markets, arresting the fall in investment and consumption. We test this mechanism and show that the type of purchases made by the Fed matter for understanding the response of the financial institutions. That is, injecting liquidity by purchasing MBS has a different effect than purchasing Treasuries.

The empirical literature on LSAPs generally finds that targeted asset purchases and/or direct extensions of credit to private borrowers by the Fed and other central banks have indeed affected equilibrium rates of return, including Ashcraft et al. (2011), Baba et al. (2006), Gagnon et al. (2010), Hancock and Passmore (2011), Sarkar and Shrader (2010), Stroebel and Taylor (2012) and

Swanson (2015).[9] In addition to providing corroborating evidence on the effects of QE on asset returns as highlighted by these papers, we complement the empirical literature by documenting heterogeneity in the effects of LSAPs on the quantity of debt issued and its unintended consequences.

Our paper is also related to a broader strand of the literature that investigates the channels through which monetary policy impacts banks' lending decisions. In a seminal paper, Kashyap and Stein (2000) provide evidence of the bank lending channel of the transmission of (conventional) monetary policy. More recently, Jimenez et al. (2014) show that a lower overnight interest rate induces less capitalized banks to lend to riskier firms, while Jimenez et al. (2012) show that for distressed banks, tighter monetary policy and worse economic conditions substantially reduce lending. Agarwal, Chomsisengphet, Mahoney and Stroebel (2015) have recently estimated the banks' marginal propensity to lend (MPL) out of a decrease in their cost of funds to show that banks are reluctant to lend to riskier borrowers in the aftermath of the crisis. Finally, Maddaloni and Peydro (2011) find that low short-term interest rates for an extended period eventually soften lending standards for household and corporate loans.[10] Rodnyansky and Darmouni (2014) look explicitly at the effect of QE on bank lending, whereas Beraja et al. (2015) highlights the heterogeneous regional effect of QE1 depending on the regions' economic conditions. We add to these studies by uncovering the impact of unconventional monetary policy on individual household refinancing, deleveraging, and consumption decisions. Finally, we also contribute to a strand of the literature investigating the redistributional consequences of monetary policy, e.g. Doepke and Schneider (2006), Fuster and Willen (2010), and Sterk and Tenreyro (2014).

The paper proceeds as follows. Section 2 provides further background on the Federal Reserve's Quantitative Easing program as well as institutional details about the credit markets we study in this paper. In Section 3, we detail the data sources used in our analysis. Section 4 presents our research design along with results on debt origination, bank lending, and household behavior. Section 5 summarizes and concludes with a discussion of policy implications.

[9] Other related papers include Chodorow-Reich (2014) and Di Maggio and Kacperczyk (2014), who study the impact of monetary policy on different sectors of the financial markets, such as pension funds, insurance companies and money market funds.

[10] See also Bernanke and Blinder (1988), Christiano and Eichenbaum (1992), Landier et al. (2011, 2013), Stein (2012) and Williamson (2012).

2 Background

In this section, we provide a brief summary of the Federal Reserve's Quantitative Easing program and discussion of how its MBS purchases were conducted on the secondary mortgage market. For reference, Table 1 provides a list of key announcement dates—dates when the Fed released significant details about future asset purchases, and Figure 2 provides a timeline of the various Fed LSAP programs. QE1 lasted from November 2008 until March 2010, and QE2 ran from November 2010 to June 2011. In September of 2011, the Fed began a program known as the Maturity Extension Program (MEP) or Operation Twist. Under the MEP, the Federal Reserve reduced the supply of longer-term Treasury securities in the market by selling and redeeming about $600 million in shorter-term Treasury securities and using the proceeds to buy longer-term Treasuries. QE3 was announced in September 2012.[11]

In late November 2008, the Fed announced its mortgage-buying program with the intent to purchase about $500 billion in mortgage-backed securities, consisting of mortgages guaranteed by Fannie Mae, Freddie Mac, and to a lesser extent, Ginnie Mae. In March 2009, the Fed announced an expansion to this program, subsequently purchasing an additional $750 billion more in mortgage-backed securities. The first quantitative easing program ended in the first quarter of 2010, with a total of $1.25 trillion in purchases of mortgage-backed securities and $175 billion of agency debt purchases. Figure 3 depicts the (gross) amount of MBS purchased and the amount of these same securities sold by the Fed during this program. During QE1, the Fed purchased both MBS and Treasuries with a greater emphasis on MBS purchases. QE2, on the other hand, was exclusively focused on Treasuries, and QE3 was roughly equally weighted between Treasuries and MBS. As Figure 3 shows, a greater fraction of each QE campaign's MBS purchases have occurred at the beginning of each program, with purchases slowly declining over the course of each LSAP campaign.[12] Notably, the Fed was effectively able to purchase $1.85 trillion (about 40% more than the usually reported $1.25 trillion amount of net purchases) by contemporaneously reselling a substantial fraction of these securities, perhaps enhancing market liquidity without further expanding the Fed balance sheet. Figure 4 shows the relative magnitude of GSE MBS net purchases compared with

[11] See Edison, Foley-Fisher and Ramcharan (2014) for a recent paper on the effect of this program on firms' financing constraints.

[12] Note that the policy of the Fed to reinvest principal prepaid on its MBS holdings into new MBS purchases results in non-zero MBS purchases even after QE3 officially ends.

the total size of the GSE-guaranteed mortgage market. During QE1, the volume of Fed purchases was similar in magnitude to the volume of new issuance of GSE-guaranteed MBS. During QE3, Fed net GSE MBS purchases were roughly half of the GSE market.

Contrary to popular perception, Fed MBS purchases did not involve buying legacy (and underperforming) MBS from banks. Instead, Fed MBS purchases were on the TBA (To-be Announced) mortgage market.[13] A key feature of the Agency MBS market is the existence of this highly liquid forward market, through which more than 90% of Agency MBS trading volume occurs and which consists predominantly of newly originated mortgages. More than 90% of Agency MBS trading volume occurs in this forward market (Vickery and Wright, 2013), with trading volumes on the order of $200 billion per day and around $100 billion delivered each month. Sellers in the TBA market are primarily mortgage originators seeking to lock-in interest rates to reduce the risk associated with letting borrowers lock-in mortgage terms well in advance of closing. Buyers in this market include MBS sponsors who are assembling Collateralized Mortgage Obligations for new securitizations.

On the day a TBA contract is traded, the buyer and seller fix the basic characteristics of the MBS to be delivered, with a 0.01% allowed variance in the par value at delivery. Generally, only six parameters of the mortgages to be delivered are specified: agency (Fannie, Freddie, or Ginnie), weighted-average maturity, weighted-average coupon (in 50 basis-point increments), price, par amount, and settlement date.[14] A separate (much smaller) market exists called the Stipulated market where CMOs with detailed information disclosures are traded. For this reason, when there is information to disclose about a MBS that enhances its value (e.g. predictors of lower early-termination risk), the STIP market is a more favorable trading platform.[15] Two days prior to TBA settlement date, the seller informs the buyer of the specific pools to be delivered and the trade is settled on an Agency-determined settlement date. To deliver these pools, the seller has either

[13] A limited number of the TBA securities purchased by the Fed at the beginning of QE1 included MBS CUSIPs that had been originated in early 2008 instead of roughly contemporaneous with Fed purchases. Still, these were GSE-eligible mortgages originated in 2008 and not the types of legacy MBS that were troubling banks, having been filled with mortgages originated under questionable underwriting standards that were deeply underwater by 2009.

[14] For example, a TBA contract might be simply specified FN3060, meaning that it represents a Fannie Mae-guaranteed MBS whose weighted average maturity and coupon are 30 years and 4.0%, respectively. Although rare, some additional characteristics may be specified, for example, the number of pools in a security, geographic composition, etc.

[15] In the Agency market, due to the default guarantees provided by Fannie, Freddie, and Ginnie, the value of MBS will primarily vary with the degree of termination risk borne by the investor since to the holder of a Agency-guaranteed mortgage, the cash flows from default and prepayment look identical. This risk may be a function of other features of the MBS not stipulated on the TBA forward contract, such as FICO, DTI, geographic location, etc.

acquired or originated Agency-eligible mortgages and paid the necessary upfront fees (known as G-fees) to have them assembled into an Agency-guaranteed pool.[16] For a variety of reasons, the vast majority of mortgages comprising TBAs are recent originations. Payment history information about seasoned mortgages can make them more valuable to trade on the STIP market (in the case of good news) or ineligible for TBA inclusion (in the case of missed payments, etc.). Adverse selection arising from the superior information set of the seller as to the termination risk of the mortgages to be delivered is mitigated by "cheapest-to-deliver" expectations and pricing by buyers and sellers (see Downing et al., 2009). This TBA contract standardization effectively commoditizes the MBS traded in TBAs, providing the TBA market with a degree of liquidity unmatched by any other secondary mortgage market, meaning that even legal requirements aside, purchasing TBAs was the only feasible option at the time.[17]

Nevertheless, the eligibility requirements for mortgages to be included in TBAs lead to sharp cross-sectional predictions on the effect of MBS purchases on loan originations. Because TBA delivery must be accomplished with Agency-eligible mortgages that are usually recent originations, the strict eligibility rules for GSE guarantees allow us to compare origination volumes by loan size. Specifically, GSE guarantees require loan sizes to be beneath published conforming loan limits (CLLs). Mortgages with a loan size exceeding geographically and time-varying CLLs (known as jumbo mortgages) are essentially ineligible for inclusion in GSE MBS. SIFMA, which regulates the TBA market, matches these requirements, preventing originators from using jumbo mortgages in TBA delivery. Many of our results below will test for a deviation in mortgage origination volume for loans just below the CLL, which should be directly affected by Fed purchases because of their TBA eligibility, and loans just above the CLL, which should only be indirectly affected by Fed MBS purchases.

[16]Note that G-fees have been increasing since 2008, a fact that should work against finding the strong differential response of GSE-eligible mortgages to QE-induced mortgage credit supply shocks.

[17]While each mortgage is a highly differentiated product, all mortgages in a given TBA contract are essentially behind a veil of ignorance and can thus be traded as a commodity. For market participants, the risk management and valuation exercises are simplified as they need consider only the risks associated with the main characteristics of the MBS. See Vickery and Wright (2013), who quantify the magnitude of the liquidity benefits of the TBA market, and Glaeser and Kallal (1997) and Vanasco (2014) for theoretical treatments of this benefit. However, this fungibility is temporary. Upon settlement and delivery, the buyer observes the complete set of characteristics of each loan pool and the market value of delivered mortgage-backed securities will incorporate this information.

3 Data

We have assembled a uniquely comprehensive database from a variety of public and proprietary data sources to conduct our analysis.

The workhorse data source we use is the Equifax's Credit Risk Insight™ Servicing McDash (CRISM) dataset, which is estimated to cover roughly 65 percent of the mortgage market during our sample the period 2008-2013. One of the features of this dataset is that it merges McDash Analytics mortgage-servicing records (from Lender Processing Services) with credit bureau data (from Equifax). This provides us with information about the characteristics of each mortgage at origination, such as the mortgage type, the size of the loan, the monthly payments, the interest rate, the borrower's FICO, as well as their behavior over time. In addition, we also observe all the other liabilities of the borrowers, such as their auto loans, HELOC and credit cards.

The unique advantage of this data is that it enables us to link multiple loans by the same borrower together, allowing us to gather more complete information about the circumstances accompanying a borrower's refinancing decision. While existing datasets follow individual mortgages over time, we can match borrowers to mortgages and observe each borrower in the credit bureau data six months before any mortgage origination and track him as the current mortgage is refinanced. This allows us to study cash-in/cash-out refinancing much more accurately. For example, by observing the outstanding amount of the old loan and the principal amount of the new loan, we can measure the dollar amount of equity that is added to the borrower's position during the refinancing process.

To disentangle changes in borrowers' credit demand from the banks' lending supply in response to unconventional monetary policy, we collect loan-level data from Reuters' DealScan database on large bank loans, which provides information about the identities of the borrower and lenders present at origination, the terms of the loan, and the purpose of the loan. DealScan primarily covers syndicated loans, that is, loan originated by one or more commercial or investment banks and sold to a syndicate of banks and other investors, such as hedge funds, mutual funds, and pension funds. Since these are syndicated loans, they are usually large, in fact, between 2008 and 2009 the median size of the loans was $268 million, and 95% were larger than $28 million. To complement this data with lender financial information, we merge the Dealscan lenders at the holding company-

level with data from the Federal Reserve FR Y-9C Consolidated Financial Statements for Bank Holding Companies for the top 100 largest banks, in terms of total assets as of the first quarter of 2008. One main difference between the coverage of commercial and industrial loans reported by the Federal Reserve Board of Governors (FRB) and Dealscan is that the FRB reports the stock of loans on the banks' balance sheet, while Dealscan collects information from Securities and Exchange Commission (SEC) filings, company statements, and media reports about the flow of loans.

4 Results

We present three main sets of results. First, we examine the response of interest rates to the LSAPs, we then turn to the changes in refinancing volume in the mortgage market. We conclude by analyzing the banking channel: the effects of the unconventional monetary policies on the banks' balance sheets.

4.1 The Effect of LSAPs on the Primary Mortgage Market

4.1.1 Interest Rate Results

We start our analysis by examining the reaction of the interest rates to the LSAPs for loans above and below the conforming loan limit. To form a comparable jumbo/conforming sample, we only consider loans that are 30-year fixed-rate first-lien mortgages with an initial LTV of 25-100% without any prepayment penalty or deferred amortization features such as balloon payment and interest only loans and secured by owner-occupied single-family houses. We also drop FHA mortgages, which have more flexible lending requirements than those for conventional loans and require insurance.

Since the composition of the borrowers changes over time, we cannot simply look at the time-series variation in the interest rates, but we need to take into account that rates change in response to borrowers' characteristics that might be different for loans originated in 2008 and in 2011. Specifically, due to stricter credit standards, mortgages feature a higher average FICO score and a lower LTV in the later part of the sample. Moreover, mortgages above and below the conforming loan limit have a different sensitivity to these mortgage characteristics. This means that we could observe differences in the interest rates charged for mortgages right below and right above the limit

due to changes in the originated mortgage characteristics.

To measure composition-adjusted interest rates over time, we estimate the following regression

$$r_{it} = \alpha_t + \beta_1(FICO_i - 720) + \beta_2(LTV_i - 0.75) + \varepsilon_{it},$$

where r_{it} is the interest rate of loan i at time t measured in basis points. We control for the difference in the FICO score and loan-to-value ratio of loan i and benchmark FICO and LTV ratios such that estimated time effects α_t capture "rate-sheet–adjusted" interest rates—interest rates for a borrower with a FICO score of 720 and an LTV ratio of 75%. In Figure 6, we plot the estimated interest rates for loans above and the conforming loan limit. There is a visible change in interest rates seen in Figure 6 during the QE1 period, during which there was a significant decline in interest rates, from 6.5% to about 5.5% and 5% for loans just above and just below the conforming loan limit, respectively. The rates for the two types of loans follow each other quite closely, but with the rates for the conforming loans decline more. The announcement of QE1 led to an increase in the jumbo spread of comparable magnitude to the increase observed in the second half of 2007, when the securitization market froze.

To quantify the average magnitude of these effects over each QE episode, Table 2 reports the estimates for the interest rates response to the announcements of the different LSAPs within a three-month (Panel I) and a six-month window (Panel II) around the commencement of each QE campaign, both for jumbo and non-jumbo loans. We augment the aggregate specification in a few ways, pooling jumbo and non-jumbo mortgages together and estimating

$$r_{igt} = X_i'\beta + \theta_1 QEj_t + \theta_2 QEj_t \cdot Jumbo_i + \gamma_{gt} + \varepsilon_{igt}$$

where QEj indicates the j^{th} QE campaign, $Jumbo_i$ is an indicator variable for whether loan i was a jumbo mortgage. In several of these specifications, we control for county $\times$ month fixed effects γ_{gt} to purge interest rates in both segments of time-varying regional shocks to credit demand. The coefficient θ_1 reports the number of basis points by which interest rates for non-jumbo mortgages fell on average in the three (or six) months immediately following the beginning of each QE campaign relative to the period immediately preceding each QE campaign's announcement. The coefficient θ_2

tells us how the jumbo-conforming spread changed in response to each QE campaign's commencement, in other words by how much more or less interest rates in the jumbo segment responded. We find that the most significant reaction is to the announcement of QE1 with a reduction in the interest rates of more than 100 basis points. Consistent with Figure 6, jumbo mortgage interest rates also decline after QE1, but the conforming rate falls by an additional 40-55 basis points. Interestingly, there is no significant response to QE2, which is motivated by the fact that the Fed was purchasing only Treasuries during that program. Finally, we find that there is a reduction of about 20-30 basis points in response to QE3. In all the specifications we control for the characteristics of the loans to ensure that the differential response of jumbo and conforming mortgages is not driven by time-varying borrower composition. In columns 3, 6, and 9, we absorb time-varying regional heterogeneity and find that our results on the jumbo-conforming spread are not driven by such shocks. The results are broadly similar when we consider a longer window around the announcement in Panel II.

Overall, these results show two robust patterns. First, interest rates decline significantly more for the conforming market during QE1, which indicates that mortgage market segmentation crucially affected its response to Fed purchases. Second, the interest rate decline is strongest for QE1, while we detect little effect for QE2, which suggests that the choice of which type of assets should be purchased by the Fed (MBS vs. Treasuries) plays a key role in determining the effectiveness of these measures.

4.1.2 Mortgage Origination Results

Inferring the impact of unconventional monetary policy from changes in the yield-curve tend to overstate its effectiveness by assuming perfect availability of credit. In particular, interest rates are observed conditional on origination, but not all mortgages are eligible for purchase by the Fed. Considering the volume of debt issuance in response to the LSAPs is an essential consideration in estimating the response of financial markets to new measures of monetary policy adopted after the crisis.

As with the interest rates, to form a comparable jumbo/conforming sample, we drop FHA mortgages and consider first-lien refinance loans for single-family houses with a current LTV of 25-120%. In order to avoid confounding the effect of QE1 with that of the introduction of the Home

Affordable Refinance Program (HARP), we also exclude from our sample the mortgages eligible for HARP with a loan-to-value ratio above 80%. Otherwise, we could observe a differential response of the mortgages exhibiting a LTV above 80% because these mortgages have a higher propensity to be refinanced through HARP.

Figure 7 plots the origination amount of refinance mortgages recorded by LPS for mortgages with loan sizes above and below the GSE conforming loan limit (CLL). While the jumbo and non-jumbo segments trend very similarly in origination counts and total volume prior to the beginning of QE1, right at the commencement of QE1, the amount of refinance origination triples (counts) or quadruples (dollar volume). The sudden increase and subsequent fading of below-CLL refinance originations coincides quite closely with the dynamics of Fed MBS purchases, as seen in Figure 5. By contrast, refinance origination above the conforming loan limit is fairly flat until a modest increase in April 2009. In other words, while the increase in the conforming spread indicates a differential response of rates depending on GSE eligibility, loan origination suggests an even deeper relationship between the allocation of credit supply and QE1 MBS purchases.

We quantify these effects on county g-by-month t-by-mortgage-market segment s origination volumes by estimating

$$\log Q_{sgt} = \beta_1 QEj_t + \beta_2 QEj_t \cdot Jumbo_s + \gamma_{sg} + \delta_{gt} + \varepsilon_{sgt}$$

where $s \in \{Jumbo, non\text{-}Jumbo\}$. For each policy event, we provide the baseline results in which we control for county fixed effects, a more restrictive specification in which we allow jumbo loans to be different within a county by including county times jumbo fixed effects, and a final specification that controls for county-by-month fixed effects. Panel I shows the results for a three-month window, while Panel II shows their robustness to a six-month window. The dependent variable is the log of the total dollar amount of monthly loan origination. Columns 1-3 show that mortgage origination increased by almost 80% during QE1, with all the effect concentrated in the conforming loan segment. In contrast to QE2 whose effect on the mortgage market was moot, QE3 generated a significant increase in mortgage origination for conforming loans, with increase between 15 and 30 percent. Panel II shows that these effects might also be larger, if we consider a longer window around the announcements.

One potential concern is that these differences among loans below and above the conforming loan limit could be an artifact of the change in the limit itself, which was enacted in January 2008. The conforming loan limit increased from about $400,000 to $700,000 for certain high-cost areas over time (see Figure 6). As mapped in Figure 7, these areas are mainly counties on the coasts that have higher land values. Although this increase occurred nearly a year before the beginning of QE1, expanding the size of the conforming market by increasing the CLL in certain areas should tilt originations from the jumbo segment to the GSE-eligible segment. To overcome this concern, we can show the change in mortgage origination exclusively in the low-cost areas that had no increase in their CLLs. Figure 10 shows that even when we restrict attention to these areas, we observe a significant and differential increase in the origination of conforming loans.

4.2 Households Deleveraging

Having shown the increase in origination of conforming loans we can also exploit the granularity of our data to study the borrowers' refinancing decision and their consumption in more detail. This allows us to investigate the effects of the LSAPs on real economic activity.

There are three types of refinancing: cash-in, in which borrowers use cash to lower their loan-to-value ratio; cash-out, in which borrowers extract equity from their homes; and no cash-out. In principle, different types of refinancing can affect different effects on consumption as they might work through three distinct channels. First, lower monthly payments lead to higher "disposable" income, which might boost consumption to the extent that borrowers have a positive marginal propensity to consume out of this additional income. Lowering interest payments is equivalent to a positive wealth shock for borrowers, which should lead to an increase in consumption as long as borrowers are not liquidity constrained. Finally, cash-in/cash-out change the stock of borrowers' liquid wealth, and cash-in refinancing may even have negative multiplier on economic activity because borrowers have to use their wealth to be able to refinance.

We are interested in assessing to what extent the increased credit availability provided by QE MBS purchases has influenced borrower borrowing and saving behavior. Specifically, we can measure whether borrowers bunch at eighty percent LTV to qualify for the Fed purchases, e.g. borrowers' propensity to cash-in refinance. We measure cash-in refinancing by linking the new refinanced loan to the unpaid balance on borrower's prior loan. We allow for $3,000 closing costs

to be rolled into the new loan without being classified as cash-in refinancing.[18] One of the main advantages of our panel data is that it allows us to observe loans amount before refinancing and to estimate the LTV prior to the refinance. We estimate bunching from the fraction of borrowers over 80% current LTV that originate a new mortgage at or below 80% LTV.

Figures 11 and 12 show that the differential availability and price of GSE eligible vs. GSE ineligible mortgages resulted in significant deleveraging. Around 40% of households who prepay from a mortgage that is initially ineligible for a GSE-guaranteed refinance deleverage, increasing their equity position via their liquid wealth. The effect is substantial: conditional on deleveraging borrowers cashed-in about $12,000 ($26,000 for jumbo-mortgage holders). The second panel of Figure 11 performs a similar exercise for the loans that refinanced through HARP. It clearly shows that this program alleviated deleveraging behavior significantly, with bunching declining from 40% to 18%. This result highlights the complementarity between unconventional monetary policy and GSE policies that affect the scope of the impact of MBS purchases.

In other words, a side effect of Fed GSE-backed MBS purchases has been to induce borrowers to deleverage. While this likely helps these households be more resilient to future shocks, it has an immediate contractionary effect on the economy (see also, e.g. Mian and Sufi, 2014). We provide direct evidence of this in Figure 13, which plots event study coefficients showing the typical effect of refinancing on new auto expenditure. This highlights the role of positive cash flow shocks from refinancing in supporting household consumption.

4.3 Bank-Lending Channel

During the financial crisis, the Federal Reserve established several facilities to provide liquidity directly to borrowers and investors in key credit markets because of the term funding markets coming under severe pressure. Due to heightened concerns about counterparty risk, investors became very reluctant to lend at maturities beyond the very shortest terms. To address the banks' funding issues, the Federal Reserve established the Term Auction Facility (TAF) in December 2007. This program enabled the Federal Reserve to provide term funds to a broader range of financial institutions and against a broader range of collateral than it could through the usual open market

[18] Average closing costs are reported here by state http://www.bankrate.com/finance/mortgages/closing-costs/closing-costs-by-state.aspx

operations. Other similar programs include the Term Securities Lending Facility (TSLF), The Asset-Backed Commercial Paper Liquidity Facility and the Commercial Paper Funding Facility (CPFF).[19]

We start our analysis of the bank lending channel by analyzing the banks' response to these liquidity facilities. We collect information on banks' total borrowing from these facilities and relate this measure to the origination of new loans as well as to their cash and MBS holdings. We measure their lending activities by distinguishing between the total loans backed by real estate assets, commercial and industrial loans and securitized loans. All these variables are normalized by the total assets as of 2008. Table 4 reports the results of estimating

$$\frac{y_{it}}{\text{Total Assets}_{i,2008q1}} = \beta \frac{\text{Liquidity Facility Borrowing}_{it}}{\text{Total Assets}_{i,2008q1}} + \alpha_i + \delta_t + \varepsilon_{it}$$

where i denotes a bank and t denotes a quarter, with $\text{Total Assets}_{i,2008q1}$ representing the total assets of bank i in the first quarter of 2008. Each column is devoted to a different dependent variable y_{it}. We control for bank fixed effects α_i and quarter fixed effects δ_t in all specifications to capture common shocks affecting all banks at the same time and for time-invariant heterogeneity between banks. The main variable of interest is the banks' total borrowing from these facilities normalized by their total assets. We find that banks that took advantage of the liquidity facilities introduced by the Fed to significantly increase their lending (columns 1-3), and their holdings of MBS (column 5), while we do not find any significant effect on their cash holdings. This seems to suggest that those programs were particularly effective in sustaining the banks' credit supply.

While the previous programs directly provided liquidity to financial institutions, the first quantitative easing program might have an impact on banks' liquidity through the purchase of mortgage backed securities in the TBA market. Specifically, banks that have real estate loans and mortgage backed securities on their balance sheets, which are prepaid due to the Fed's program, experience a cash injection. Then, we would expect that banks with a higher fraction of real-estate assets on

[19]The TSLF offered Treasury securities held by the System Open Market Account (SOMA) for loan over a one-month term against other program-eligible general collateral. The Asset-Backed Commercial Paper facility was a lending facility that provided funding to bank holding companies to finance their purchases of high-quality asset-backed commercial paper (ABCP) from money market mutual funds. Under the CPFF program, the Federal Reserve Bank of New York provided three-month loans to the CPFF LLC, a specially created limited liability company (LLC) that used the funds to purchase commercial paper directly from eligible issuers. Source: http://www.federalreserve.gov/monetarypolicy/bst.htm .

their balance sheets would benefit the most from this program. We formally test whether QE1 had any effect on banks' lending behavior in Table 5 by estimating how bank balance-sheet categories changed in the two quarters following the beginning of QE1 relative to the two quarters before by estimating

$$log(y_{it}) = \beta' QE1_t \cdot \frac{RE\ Related\ Assets_{i,2008q1}}{\text{Total Assets}_{i,2008q1}} + \alpha_i + \delta_t + \varepsilon_{it} \tag{1}$$

where y again represents various categories of bank assets (cash, real estate loans, commercial and industrial loans, and MBS holdings). $QE1_t$ is an indicator equal to 1 if quarter t is in the two quarters following the beginning of QE1, i.e. first and second quarter of 2009. Our main right-hand side variable is the interaction between the QE1 indicator, which is equal to 1 after the introduction of the first quantitative program and Fraction of RE Assets normalized by total assets and measured in the pre-period, specifically, in the first quarter of 2008. The hypothesis is that banks with more significant holdings of these assets are going to experience a larger cash inflow due to prepayment of these mortgages, which might lead them to increase their lending.

In column 1, we test whether after the introduction of QE1 the banks with higher real estate holdings increase their cash holdings, which include both cash on hand and cash deposited as Excess Reserves at the Fed. The Fed pays for its purchases by issuing reserves, so the immediate consequence of asset purchases is to increase reserves for the Primary Dealer selling to the Fed. However, banks are always free to redeem their excess reserves as currency, which they could use to finance lending or asset purchases. Moreover, because MBS purchases primarily consisted of refinance mortgages, each of these mortgages involves the prepayment of a prior mortgage, resulting in direct cash flow to the owner of the prior mortgage note (often held inside previously issued MBS). We find that the strongest effect of QE exposure is indeed on cash holdings, with a one standard deviation increase in our independent variable predicting an increase of about 7 percent in cash holdings. Column 2 shows that there is a statistically significant, but economically less important, reduction in the volume of real estate loans. Whereas column 3 and 4 show that there is no effect for C&I loans and MBS. In sum, we find that the banks that benefit the most from the LSAPs increase their cash holdings in response to QE1, but did not increase their lending.[20]

[20] Our identification strategy, by focusing on a narrow window around the quantitative easing program, is only able to detect the short-run response to the Fed purchases. However, we are not able to rule out a beneficial effect of QE1 on the banks' financial conditions which eventually lead to an increase in economic activity.

The absence of a bank lending channel in response to the first quantitative easing program might be the result of the extremely weak economic conditions in 2009 rather than a general inneffectiveness of MBS purchase programs. To test this hypothesis, we relate the banks' lending activities to the third quantitative easing program in 2012. Formally, we test whether QE3 had any effect on banks' lending behavior in Table 6 by estimating a parallel version of equation (1)

$$og(y_{it}) = \beta' QE3_t \cdot \frac{RE\ Related\ Assets_{i,2012q1}}{\text{Total Assets}_{i,2012q1}} + \alpha_i + \delta_t + \varepsilon_{it}$$

where y represents the same categories of bank assets, i.e. cash, real estate loans, commercial and industrial loans, and MBS holdings as above. $QE3_t$ is an indicator equal to 1 if quarter t is in the two quarters following the beginning of QE3, i.e. third and fourth quarter of 2012. As before, we hypothesize that banks with a larger exposure to real estate assets should benefit the most from the Fed purchases, which could result in increased lending. Again, our main right-hand side variable is the interaction between the QE3 indicator and Real Estate-related Assets (normalized by total assets) and measured in the pre-period, specifically, in the first quarter of 2012. Column 1 shows that, as in the case of QE1, Fed purchases led to a significant increase in banks' cash holdings. However, the economic magnitude of this effect is significantly lower. Columns 2 and 3 show that, in contrast to what we found in Table 5 for QE1, banks significantly increased their lending both through real estate loans and commercial and industrial loans immediately after the institution of QE3, whereas Column 4 shows no significant effect on the holdings of MBS. In sum, these results suggest that while banks increased their cash holdings during both quantitative easing programs, they deployed the extra liquidity towards new loan origination only when the financial markets recovered in 2012.

One potential concern with the flypaper-effect findings in Table 5 about QE1 is the difficulty to disentangle between credit demand and supply. That is, it would be possible to explain the previous results by arguing that banks would be willing to lend the additional funds received through the LSAPs, but that they are constrained by the distressed economy and the lack of investment opportunities. To overcome this difficulty, we collect loan-level information from Dealscan, which covers large syndicated loans. The main advantage of this dataset is that it can be matched to the lender's information from the Federal Reserve FR Y-9C Consolidated Financial Statements

for Bank Holding Companies in order to allow us to perform loan-level analysis. We can then complement the previous results on the bank lending channel by investigating if borrowers see their credit supply increase or decrease after QE1. Table 7 reports the results with the main variable of interest being, as before, the interaction between the QE1 indicator and the lender's fraction of real estate assets in the pre-period. The dependent variable is the log of the loan amount that bank i granted to firm j at time t. To make sure that our results are not confounded by any other policy intervention or other market movements, we restrict attention to the two-quarter window around the QE1 announcement.

In column 1 we control for time, lenders and borrowers fixed effects. We do not find a significant differential banks' response to QE1 depending on their holdings of real estate assets. In column 2 we control for borrowers times quarter fixed effects to capture any time-varying heterogeneity at the borrower level. That is, the specification in column 2 effectively compares the lending behavior of different banks with respect to the same borrower in the same quarter before and after QE1. The coefficient is negative, but it is not significant and its magnitude is very small. This result is confirmed in columns 3 and 4 when we also control for the interaction between the introduction of QE1 and measures of bank's health: the change in market capitalization and the fraction of deposits. Finally, Figure 14 reports event study coefficients of the specification in column 1. Although banks with a high fraction of their total assets in real-estate related holdings are unconditionally increasing their cash holdings prior to QE1 in response to current and anticipated distress, conditional on bank fixed-effects and time-varying bank controls, the pre-trends are close to zero and insignificant. In the quarters following the start of QE1, the firms most exposed to prepayments induced by the surge of QE1-related refinancings increase their cash holdings, suggesting that the near-term (first three quarters) effect of QE1 was to increase the cash and Excess Reserves held by the banks that benefitted the most.

5 Conclusion

Prior to the fall of 2007, the Fed had largely held Treasury securities on its balance sheet. However, in response to the financial crisis, the Fed started several new programs—new liquidity facilities (under which the Fed lent directly to certain sectors of the economy) and targeted purchases of

trillions of dollars of long-term Treasuries and GSE-guaranteed mortgage-backed securities. The role played by these unconventional monetary policies has been the subject of ongoing debate.

In this paper, we focus on detecting and quantifying the transmission mechanism of unconventional monetary policy through banks.[21] Under the bank-lending channel (where capital is scarce for banks and new capital inspires new lending) or the bank-portfolio rebalancing channel (where banks have a desired duration mix and are nudged into other long-duration asset markets), Fed purchases of long-duration assets will have spillover effects, easing credit to other sectors of the economy as capital is freely reallocated across the economy. In contrast to this view, using rich bank- and loan-level microdata, we find strong evidence of a "flypaper effect" of unconventional monetary policy during QE1, which we term the direct lending channel, where money injected into the banking sector by Fed QE purchases sticks where it lands. There appears to be little evidence of a bank-lending channel for unconventional monetary policy during QE1 when the banking sector was most distressed (and market segmentation seems particularly acute). During QE1, banks appear to respond to Fed MBS purchases by originating mortgages to sell to the Fed but did not seem to reallocate proceeds of such sales (or the prepayments induced by QE-era refinances) towards other forms of lending. Instead of reallocating their capital through increased lending or asset purchases, we show that banks held most of this money in Excess Reserves at the Fed during QE1. The targeted nature of the Fed's MBS purchase program coupled with the lack of reallocation by banks means that Fed purchases *de facto* allocated credit towards the mortgage market and within the mortgage market towards GSE-eligible borrowers. An immediate implication of this lack of reallocation is that the borrowers who benefitted the most from monetary stimulus during the recession had relatively high levels of home equity or cash-on-hand and disproportionately lived in the least hard-hit areas.

For identification, we use cross-sectional conditional variation in pre-QE real estate holdings as a predictor of the degree to which banks benefit from QE purchases. We also contrast the differential response of segments within the mortgage market, where we can test for heterogenous impacts of QE across very similar debt contracts to comparable borrowers. QE passed through to borrowers who were able to refinance into mortgages bundled into MBS purchased by the Fed—but

[21] To be clear, there could be many other entities besides banks through which unconventional monetary policy is transmitted. This paper focuses on banks and not on hedge funds, money market mutual funds, households' holdings, etc., each of which may have important responses to unconventional monetary policy

not nearly as much to borrowers who couldn't qualify for a GSE-eligible mortgage.

Unlike previous studies that have focused exclusively on the effects LSAPs on interest rates and asset returns, we show that focusing on prices instead of quantities understates the degree of heterogeneity in the real effects of LSAPs. Specifically, the increase in originations caused by QE was concentrated in the conforming segment of the mortgage market and during the implementation of QE1, while QE2 had similar effects across market segments. Moreover, by the time the banking sector had stabilized, when QE3 was announced, banks benefitting the most from Fed MBS purchases did increase loan originations across market sectors (e.g. commercial and industrial loans) and segments (e.g. jumbo and conforming mortgages). This highlights a main takeaway from our analysis: the effectiveness of unconventional monetary policy crucially depends on the composition of the assets purchased by the Fed.

Finally, exploiting the ability of our data to link mortgage across borrowers, we document an unintended consequence of Fed MBS purchases. Because banks during QE1 did not reallocate capital to non-conforming segments of the mortgage market, many households initially ineligible for a conforming mortgage (current loan-to-value ratios exceeding 80% or loan balances over the conforming loan limit) delevered by bringing cash to closing ("cash-in refinancing") to take advantage of low interest rates during the height of QE1 MBS purchases. For example, 43% of borrowers that refinanced an existing loan with an outstanding balance exceeding the conforming loan limit took out a refinance loan at or below the conforming loan limit, on average spending $26,000 to do so. This likely mitigated the multiplier effects of lower interest rates, and we show that refinancers realizing a rate reduction generally increase their durable goods consumption right after refinancing. This crowding in to the conforming mortgage market segment highlights that the allocative effects of QE can mitigate its stimulative effects by affecting households consumption and savings decisions.

There are several implications of these findings for designing effective unconventional monetary policy. First, not only the duration but also the type of the securities purchased matters for the transmission LSAPs to real economic activity. Federal Reserve Act provisions that restrict the Fed to purchasing only government-guaranteed debt have consequences in allocating credit to certain sectors (i.e. housing) and particular segments of those sectors (i.e. conforming mortgages), with undesirable implications for redistribution and the return on unconventional monetary stimulus.

Even operating within the legal constraints that govern Federal Reserve purchases, it appears preferable for LSAPs to purchase MBS directly instead of Treasuries during times when banks are reluctant to lend. Our results also suggest that Federal Reserve interventions could have been more effective if they had provided more direct funding to banks for lending to small business and households similar to what the Bank of England did in its "The Lending for Funding Scheme." Under such a program, the central bank provides very inexpensive credit to banks, accepting newly originated loans to firms and households as collateral.[22] Here, too, the Fed's ability to stimulate the banking sector is inhibited by law allowing them to lend only through the discount window at a penalty rate without invoking Section 13(3) of the Federal Reserve Act. We find that the bank-lending channel was relatively inoperable during QE1. To the extent that this was attributable to the "inflation brakes" employed by the Fed such as Reverse Repo and paying interest on Excess Reserves, the intensity of such actions could be reevaluated. Finally, we demonstrate a strong interaction between GSE policies and programs and the effectiveness of MBS purchases. Programs like HARP had a role in extending credit to the households who need it most, as did the significant expansion in FHA market share during the crisis. Related, a more robust PMI industry could provide necessary credit enhancements for GSE guarantees to reach more households during a recession.

[22]While U.S. programs such as TALF and CPFF ostensibly encouraged lending to businesses and households, their main focus was providing liquidity to (and preventing a further collapse of) securitization markets. The high cost of credit under those programs limited their scope as market confidence returned (Ashcraft et al., 2012).

References

Adelino, M., A. Schoar, and F. Severino (2013). Credit Supply and House Prices: Evidence from Mortgage Market Segmentation. NBER Working Paper 17832.

Agarwal, S., S. Chomsisengphet, N. Mahoney, and J. Stroebel (2015). Do Banks Pass Through Credit Expansions? The Marginal Profitability of Consumer Lending During the Great Recession. Technical report, National Bureau of Economic Research.

Ashcraft, A., N. Garleanu, and L. H. Pedersen (2011). Two monetary tools: Interest rates and haircuts. *NBER Macroeconomics Annual 25*, 143–180.

Baba, N., M. Nakashima, Y. Shigemi, and K. Ueda (2006). The Bank of Japan's Monetary Policy and Bank Risk Premiums in the Money Market. *International Journal of Central Banking*.

Beraja, M., A. Fuster, E. Hurst, and J. Vavra (2015). Regional heterogeneity and monetary policy. Staff Report, Federal Reserve Bank of New York.

Bernanke, B. S. (2012). Monetary Policy since the Onset of the Crisis. In *Federal Reserve Bank of Kansas City Economic Symposium*, Volume 31, Jackson Hole, Wyoming.

Bernanke, B. S. (2015). *Courage to Act: A Memoir of a Crisis and Its Aftermath*. New York: Norton.

Bernanke, B. S. and A. S. Blinder (1988). Credit, Money, and Aggregate Demand. *American Economic Review 78*(2), 435–39.

Best, M. C., J. Cloyne, E. Ilzetzki, and H. J. Kleven (2015). Interest Rates, Debt and Intertemporal Allocation: Evidence From Notched Mortgage Contracts in the UK.

Brunnermeier, M. K. and Y. Sannikov (2015). The I theory of money. Working Paper, Princeton University.

Chodorow-Reich, G. (2014). Effects of Unconventional Monetary Policy on Financial Institutions. *Brookings Papers on Economic Activity*, 155.

Christiano, L. J. and M. Eichenbaum (1992). Liquidity Effects and the Monetary Transmission Mechanism. *American Economic Review*, 346–353.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy 113*(1), 1–45.

DeFusco, A. A. and A. Paciorek (2015). The interest rate elasticity of mortgage demand: Evidence from bunching at the conforming loan limit. FEDS Working Paper 2014-11.

Del Negro, M., G. B. Eggertsson, A. Ferrero, and N. Kiyotaki (2011). The great escape? A quantitative evaluation of the Fed's liquidity facilities. FRB of New York Staff Report 520.

Di Maggio, M. and M. Kacperczyk (2014). The Unintended Consequences of the Zero Lower Bound Policy. Columbia Business School Research Paper 14-25.

Di Maggio, M., A. Kermani, and R. Ramcharan (2014). Monetary Policy Pass-Through: Household Consumption and Voluntary Deleveraging. Columbia Business School Research Paper 14-24.

Doepke, M. and M. Schneider (2006). Inflation and the redistribution of nominal wealth. *Journal of Political Economy 114*(6), 1069–1097.

Downing, C., D. Jaffee, and N. Wallace (2009). Is the market for mortgage-backed securities a market for lemons? *Review of Financial Studies 22*(7), 2457–2494.

Drechsler, I., A. Savov, and P. Schnabl (2014). The Deposits Channel of Monetary Policy. Unpublished manuscript.

Eggertsson, G. B. et al. (2003). Zero bound on interest rates and optimal monetary policy. *Brookings Papers on Economic Activity 2003*(1), 139–233.

Foley-Fisher, N., R. Ramcharan, and E. G. Yu (2014). The Impact of Unconventional Monetary Policy on Firm Financing Constraints: Evidence from the Maturity Extension Program. *Available at SSRN 2537958*.

Fuster, A. and J. Vickery (2015). Securitization and the fixed-rate mortgage. *Review of Financial Studies 28*(1), 176–211.

Fuster, A. and P. Willen (2010). $1.25 trillion is still real money: Some facts about the effects of the federal reserve's mortgage market investments. FRB of Boston Public Policy Discussion Paper 10-4.

Gagnon, J., M. Raskin, J. Remache, and B. P. Sack (2010). Large-scale asset purchases by the Federal Reserve: did they work? FRB of New York Staff Report 441.

Gertler, M. and P. Karadi (2011). A model of unconventional monetary policy. *Journal of Monetary Economics 58*(1), 17–34.

Glaeser, E. L. and H. D. Kallal (1997). Thin markets, asymmetric information, and mortgage-backed securities. *Journal of Financial Intermediation 6*(1), 64–86.

Greenwood, R., S. G. Hanson, and G. Y. Liao (2015). Price Dynamics in Partially Segmented Markets. HBS Working Paper.

Greenwood, R. and D. Vayanos (2014). Bond supply and excess bond returns. *Review of Financial Studies 27*(3), 663–713.

Hancock, D. and W. Passmore (2011). Did the Federal Reserve's MBS purchase program lower mortgage rates? *Journal of Monetary Economics 58*(5), 498–514.

Jimenez, G., S. Ongena, and J.-L. Peydro (2012). Credit supply and monetary policy: Identifying the bank balance-sheet channel with loan applications. *American Economic Review 102*(5), 2301–2326.

Jimenez, G., S. Ongena, J.-L. Peydro, and J. Saurina (2014). Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking? *Econometrica 82*(2), 463–505.

Kashyap, A. K. and J. C. Stein (2000). What do a million observations on banks say about the transmission of monetary policy? *American Economic Review*, 407–428.

Krishnamurthy, A. and A. Vissing-Jorgensen (2011). The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy. *Brookings Papers on Economic Activity*, 215.

Krishnamurthy, A. and A. Vissing-Jorgensen (2013). The ins and outs of LSAPs. In *Economic Symposium Conference Proceedings. Jackson Hole, WY: Federal Reserve Bank of Kansas City*.

Landier, A., D. Sraer, and D. Thesmar (2011). The risk-shifting hypothesis: Evidence from subprime originations. TSE Working Paper 11.

Landier, A., D. Sraer, and D. Thesmar (2013). Banks' Exposure to Interest Rate Risk and The Transmission of Monetary Policy. National Bureau of Economic Research Working Paper.

Maddaloni, A. and J.-L. Peydró (2011). Bank risk-taking, securitization, supervision, and low interest rates: Evidence from the Euro-area and the US lending standards. *Review of Financial Studies 24*(6), 2121–2165.

Mian, A. and A. Sufi (2014). What Explains the 2007–2009 Drop in Employment? *Econometrica 82*, 2197–2223.

Rodnyansky, A. and O. Darmouni (2014). The Effects of Quantitative Easing on Bank Lending Behavior. SSRN Working Paper 2669009.

Rogers, J. H., C. Scotti, and J. H. Wright (2014). Evaluating asset-market effects of unconventional monetary policy: a multi-country review. *Economic Policy 29*(80), 749–799.

Rotemberg, J. and M. Woodford (1997). An optimization-based econometric framework for the evaluation of monetary policy. *NBER Macroeconomics Annual 12*, 297–361.

Sarkar, A. and J. Shrader (2010). Financial amplification mechanisms and the Federal Reserve's supply of liquidity during the crisis. *Economic Policy Review 16*(1), 55.

Stein, J. C. (2012). Monetary Policy as Financial Stability Regulation. *The Quarterly Journal of Economics 127*(1), 57–95.

Sterk, V. and S. Tenreyro (2014). The Transmission of Monetary Policy Operations through Redistributions and Durable Purchases. Working Paper.

Stroebel, J. and J. B. Taylor (2012). Estimated Impact of the Federal Reserve's Mortgage-Backed Securities Purchase Program. *International Journal of Central Banking*.

Swanson, E. T. (2015). Measuring the Effects of Unconventional Monetary Policy on Asset Prices. Technical report, National Bureau of Economic Research.

Vanasco, V. M. (2014). Information Acquisition vs. Liquidity in Financial Markets. Working Paper.

Vickery, J. I. and J. Wright (2013). TBA trading and liquidity in the agency MBS market. *Economic Policy Review 19*(1), 1–18.

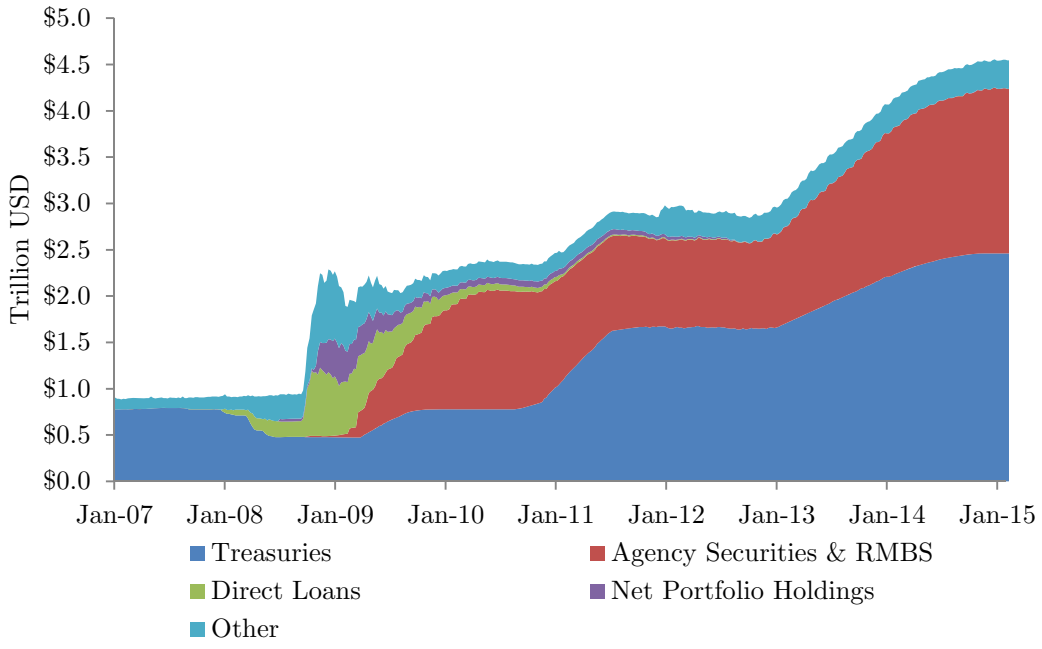
Wallace, N. (1981). A Modigliani-Miller theorem for open-market operations. *American Economic Review*, 267–274.

Williamson, S. D. (2012). Liquidity, monetary policy, and the financial crisis: A new monetarist approach. *American Economic Review 102*(6), 2570–2605.

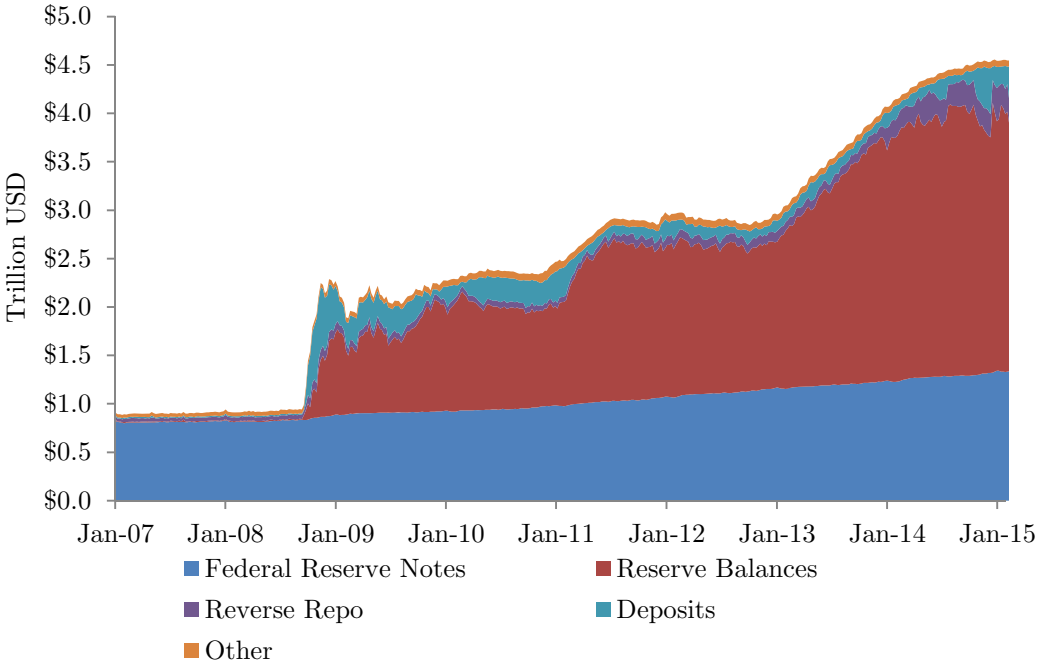
Woodford, M. and V. Curdia (2011). The Central Bank's Balance Sheet as an Instrument of Monetary Policy. *Journal of Monetary Economics 58.1*(136), 54–79.

Figure 1. Federal Reserve Balance Sheet

Panel I. Federal Reserve Assets

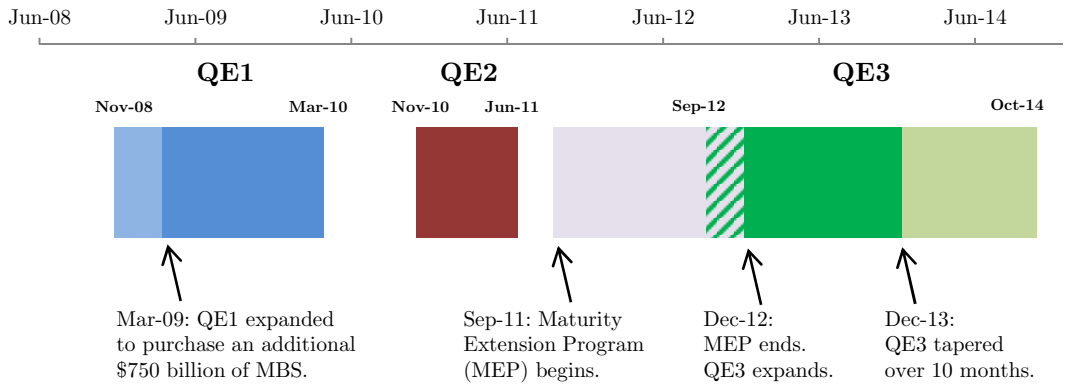


Panel II. Federal Reserve Liabilities



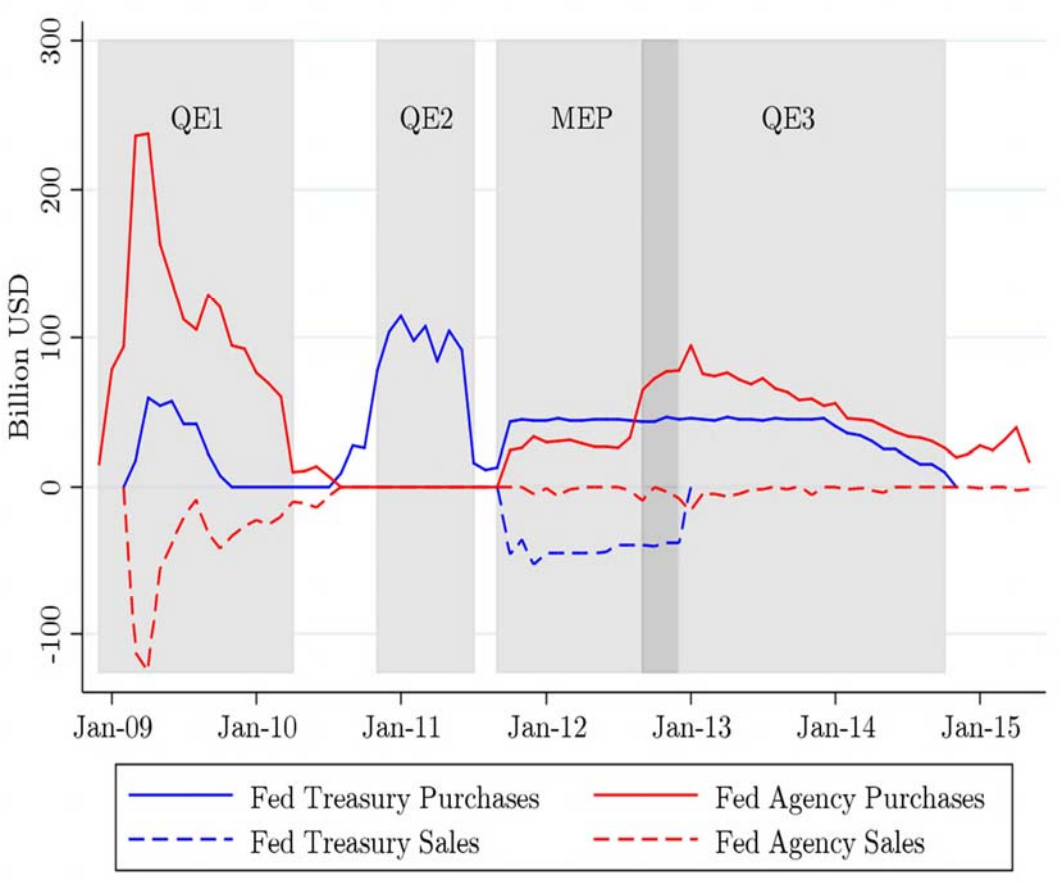
Notes: Graphs shows the size and the composition of the Fed Balance sheet from 2007-2015 with assets plotted in Panel I and liabilities in Panel II. Source: Fed H4.1 weekly reports.

Figure 2. Quantitative Easing Timeline



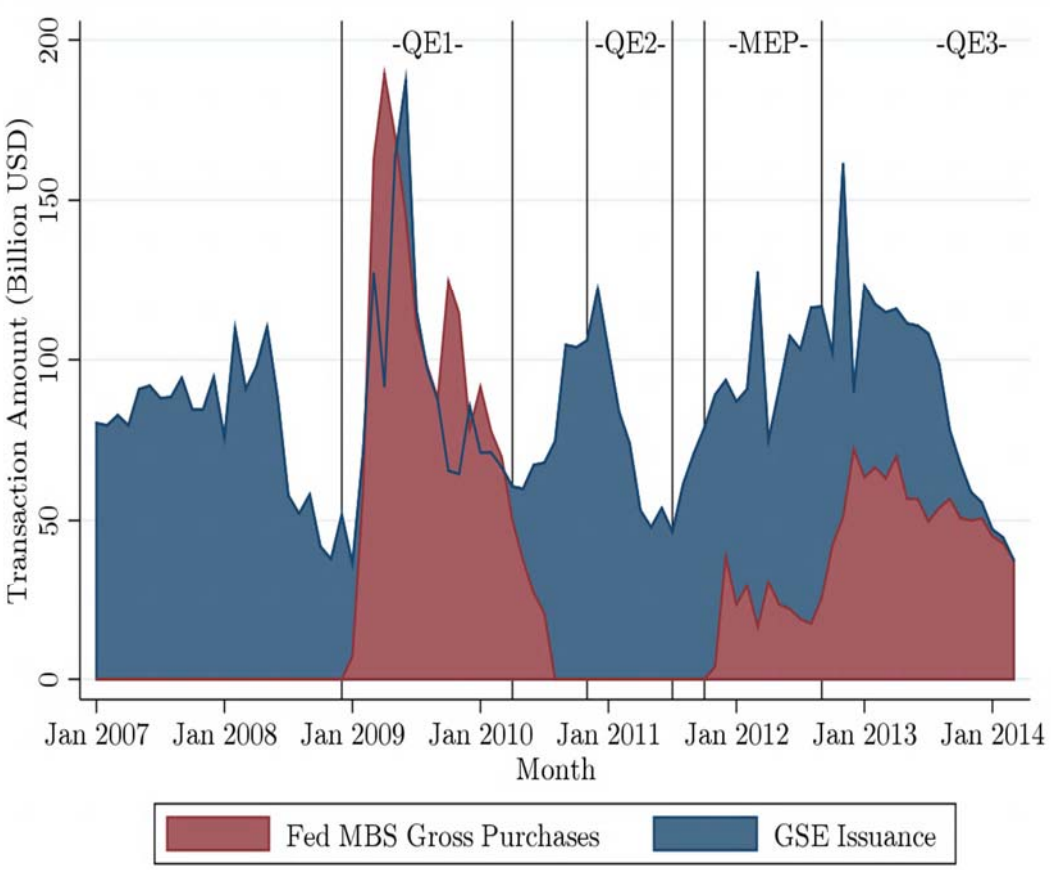
Note: Figure plots the timeline of the main LSAPs implemented after the financial crisis.

Figure 3. Federal Reserve Asset Purchases & Sales



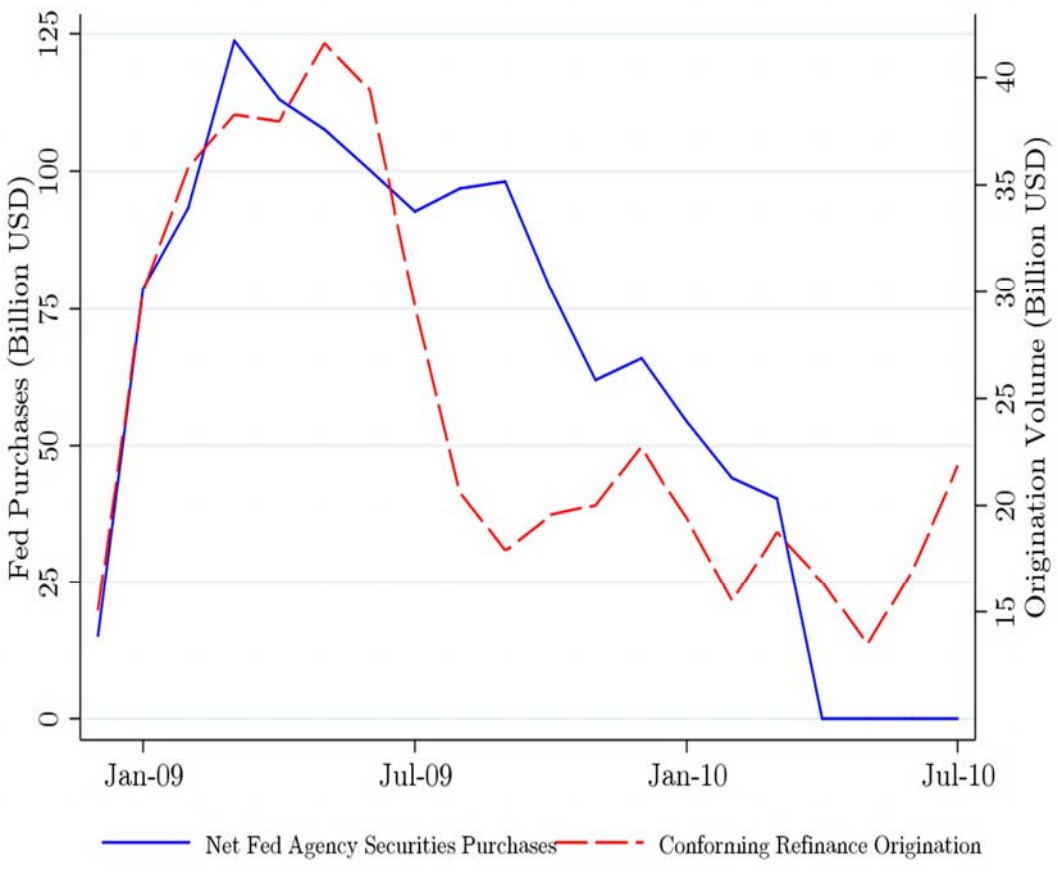
Notes: Figure plots monthly gross transaction amounts for the purchase and sale of mortgage-backed securities (in red) and Treasuries (in blue) by the Fed during the each quantitative easing operation. MEP shading represents the period of the Matury Extension Program, also known as Operation Twist, that involved the swapping of short- and long-term Treasuries. Source: NY Fed Open Market Operations Data.

Figure 4. Fed GSE MBS Net Purchases vs. Monthly GSE Issuance



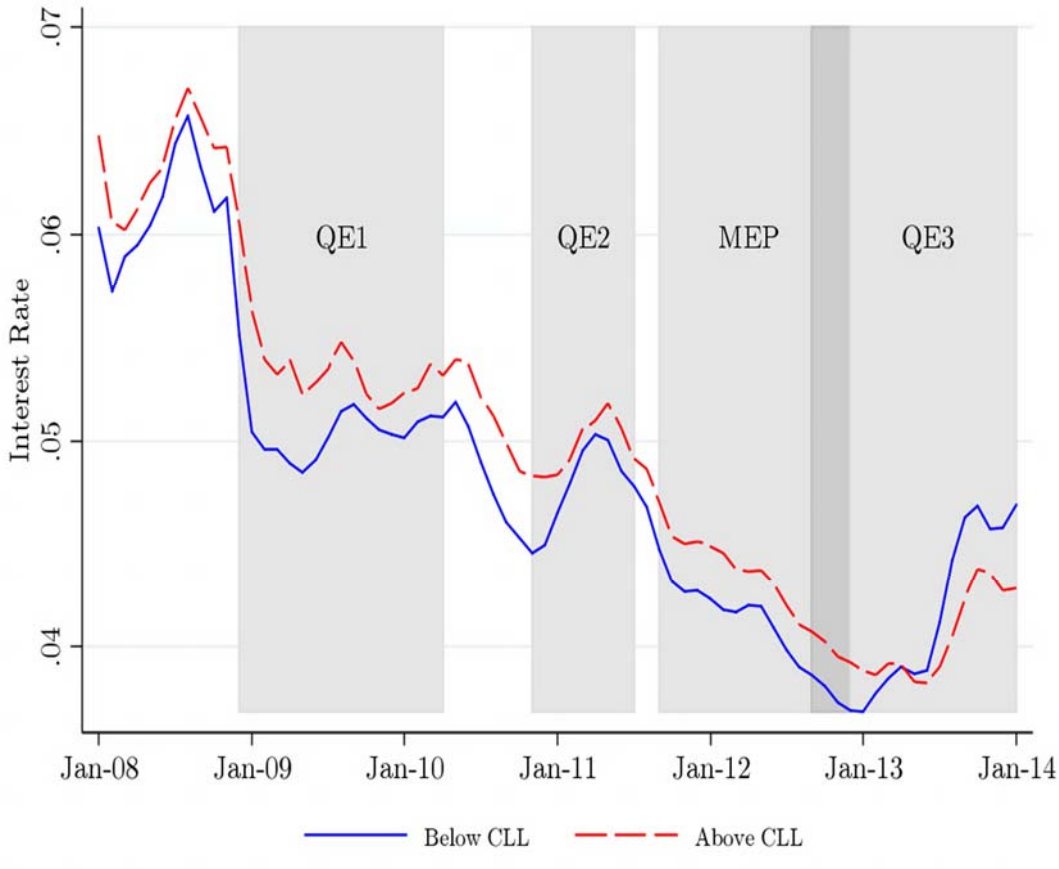
Notes: Figure plots the transaction amounts for the purchase of mortgage-backed securities by the Fed and the issuance of GSE securities during the three quantitative easing operations. Source: NY Fed Open Market Operations Data and SIFMA.

Figure 5. Fed Gross MBS Purchases vs. Conforming Origination Volume



Notes: Figure plots the monthly origination amount of refinance mortgages (right axis) recorded by LPS against the net monthly amount of Fed purchases of Agency securities (left axis).

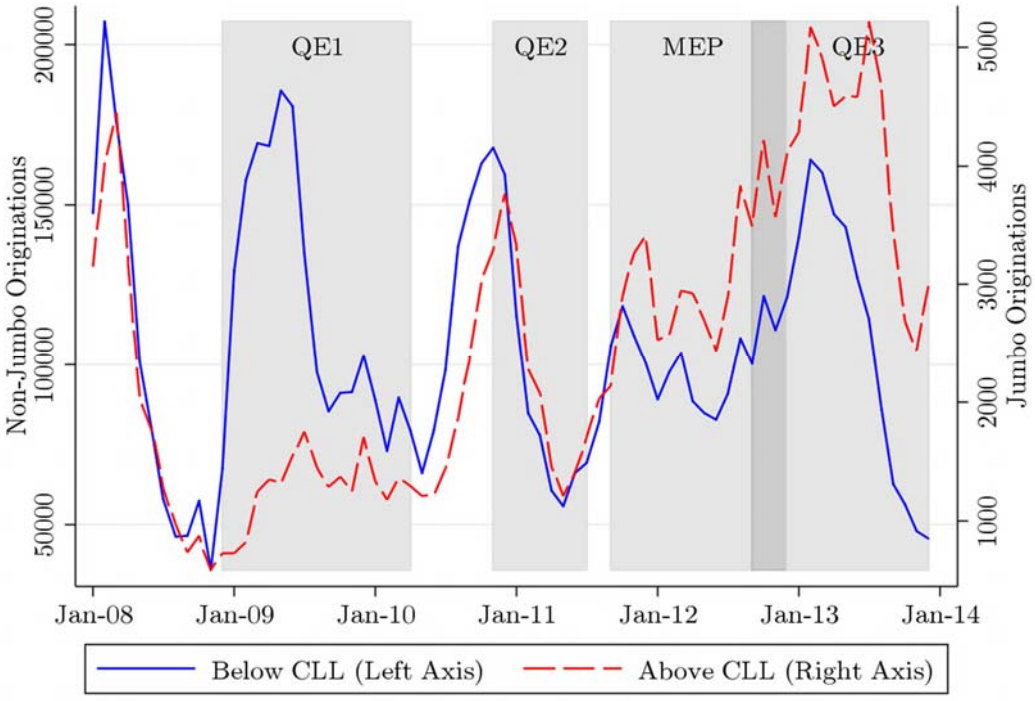
Figure 6. Interest Rates for Conforming and Jumbo Refinance Loans



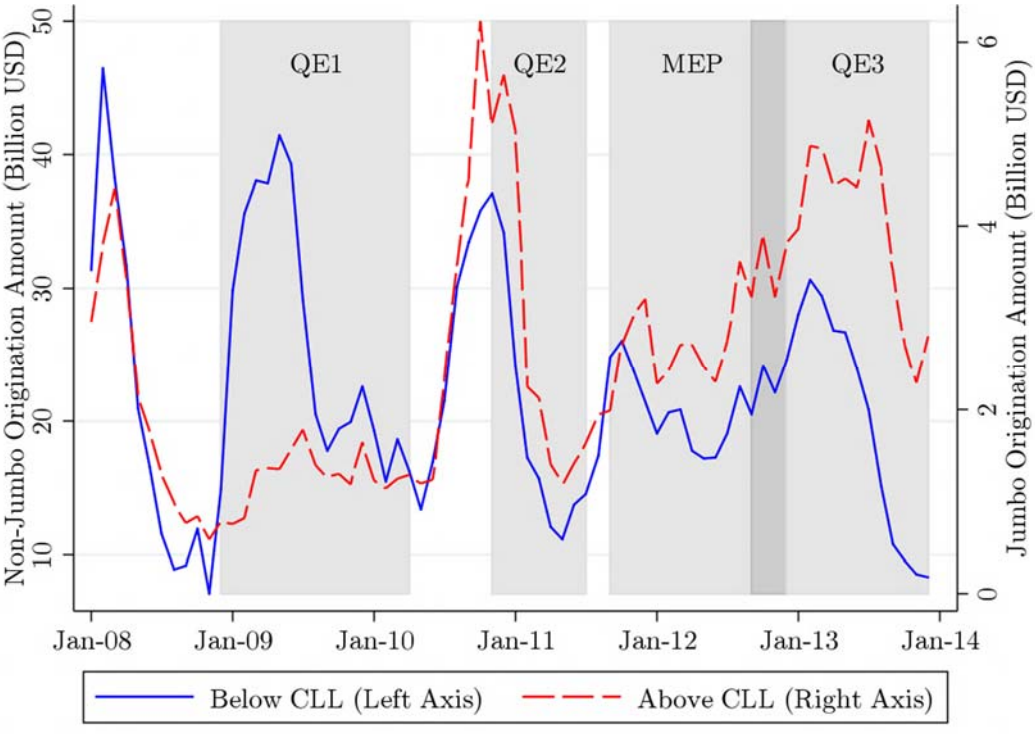
Notes: Figure plots the estimated monthly interest rates for refinance loans with a loan-to-value ratio of 75% and a FICO score of 760 and 30 year fixed rate mortgage. The estimates are based on all refinance loans in LPS with LTV less or equal to 80% and adjusted for the LTV and credit score of the borrower. See Section 5.1 for more details.

Figure 7. Refinance Origination Volume

Panel I. Number of Originations

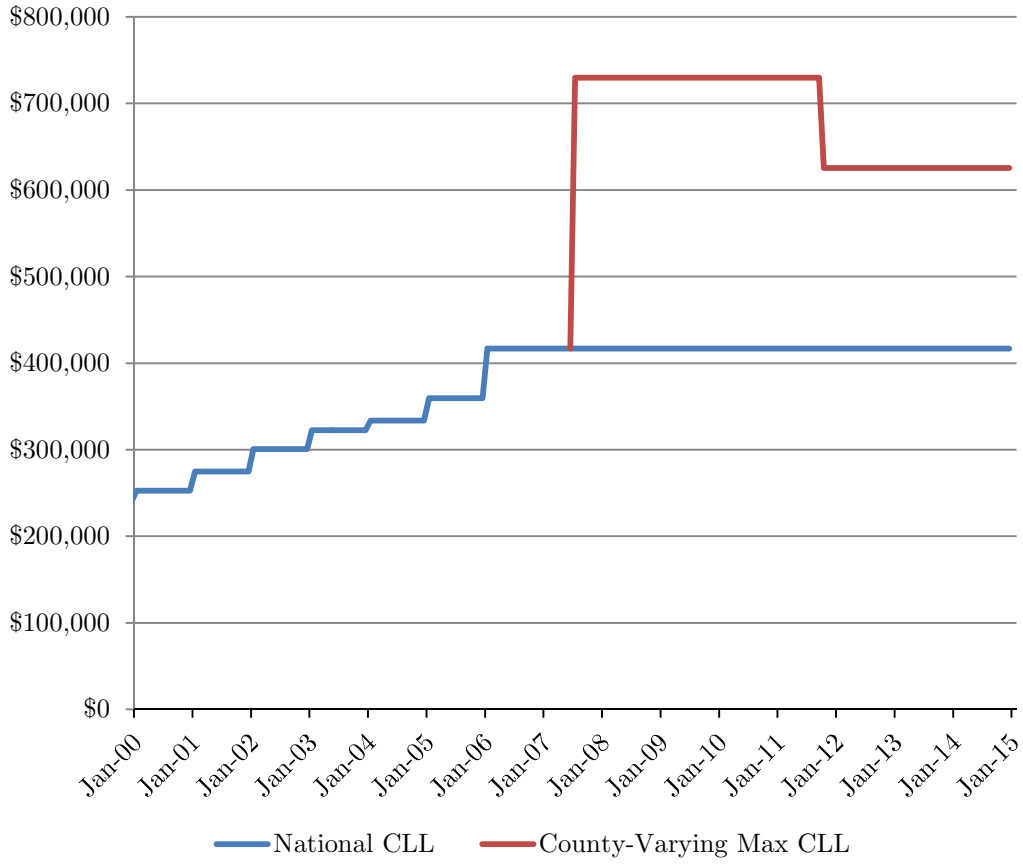


Panel II. Origination Volume



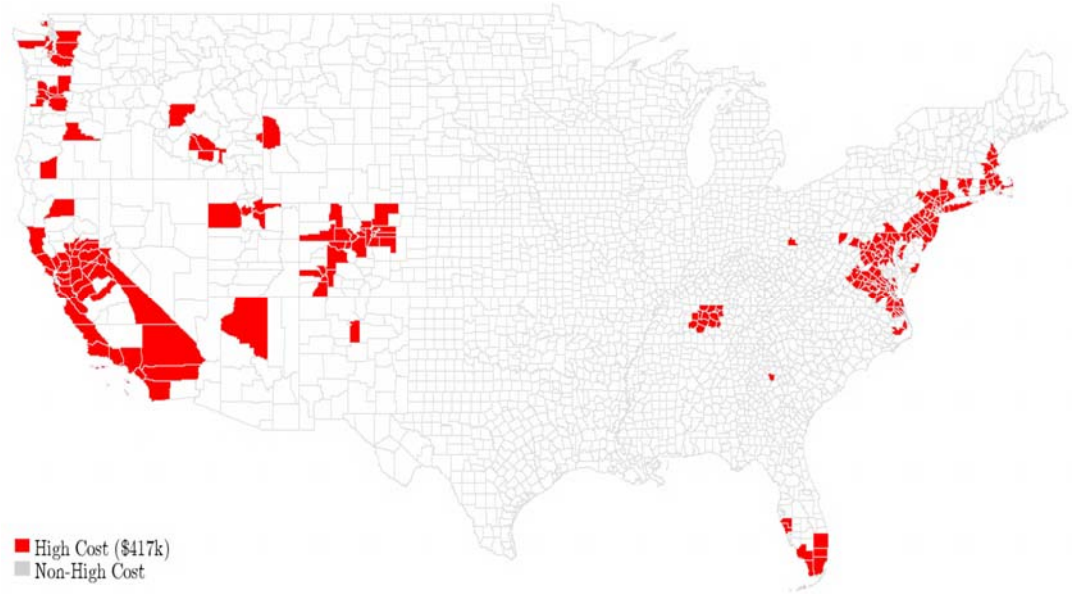
Notes: Figure plots the number of originations (top panel) and the origination volume (bottom panel) of refinance mortgages below the conforming loan limit and above the conforming loan limit as recorded by LPS. FHA loans are excluded from the data.

Figure 8. Conforming Loan Limits



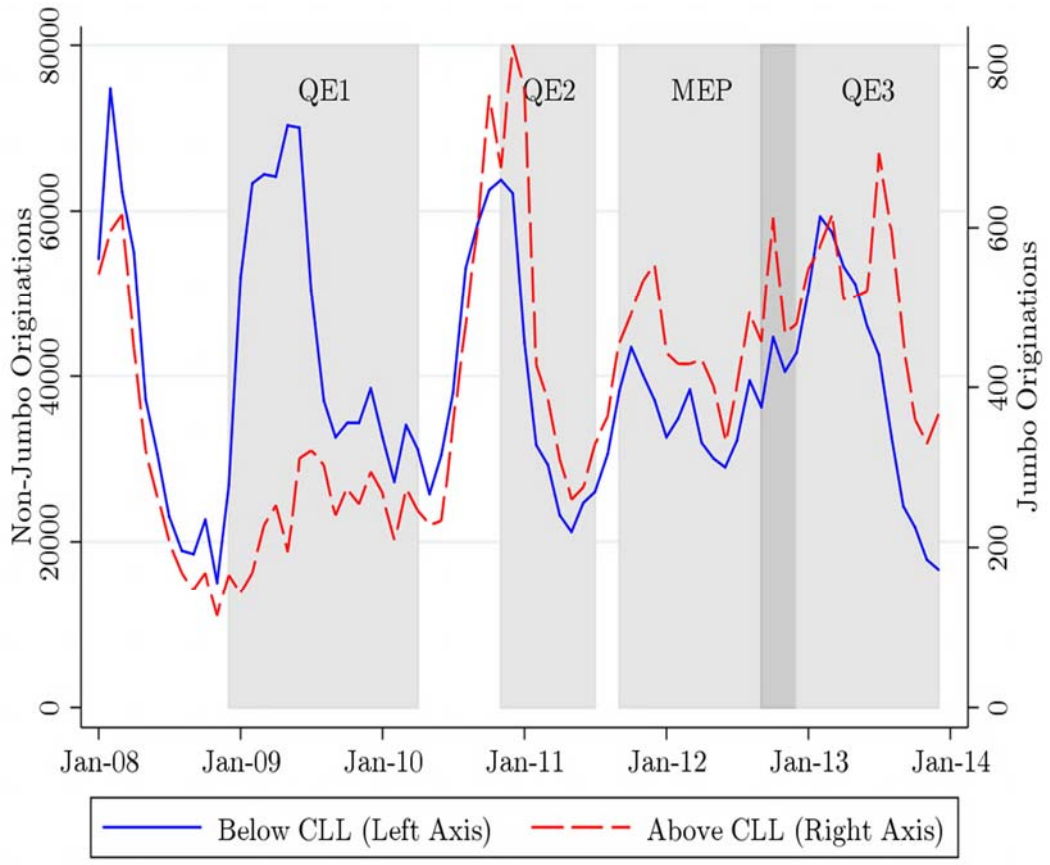
Notes: Figure plots the national conforming loan limit over time and its maximal increase among certain high-cost counties in early 2008. Some of these temporary high-cost exemptions expired on October 1, 2011.

Figure 9. The Geography of High-Cost County Designation



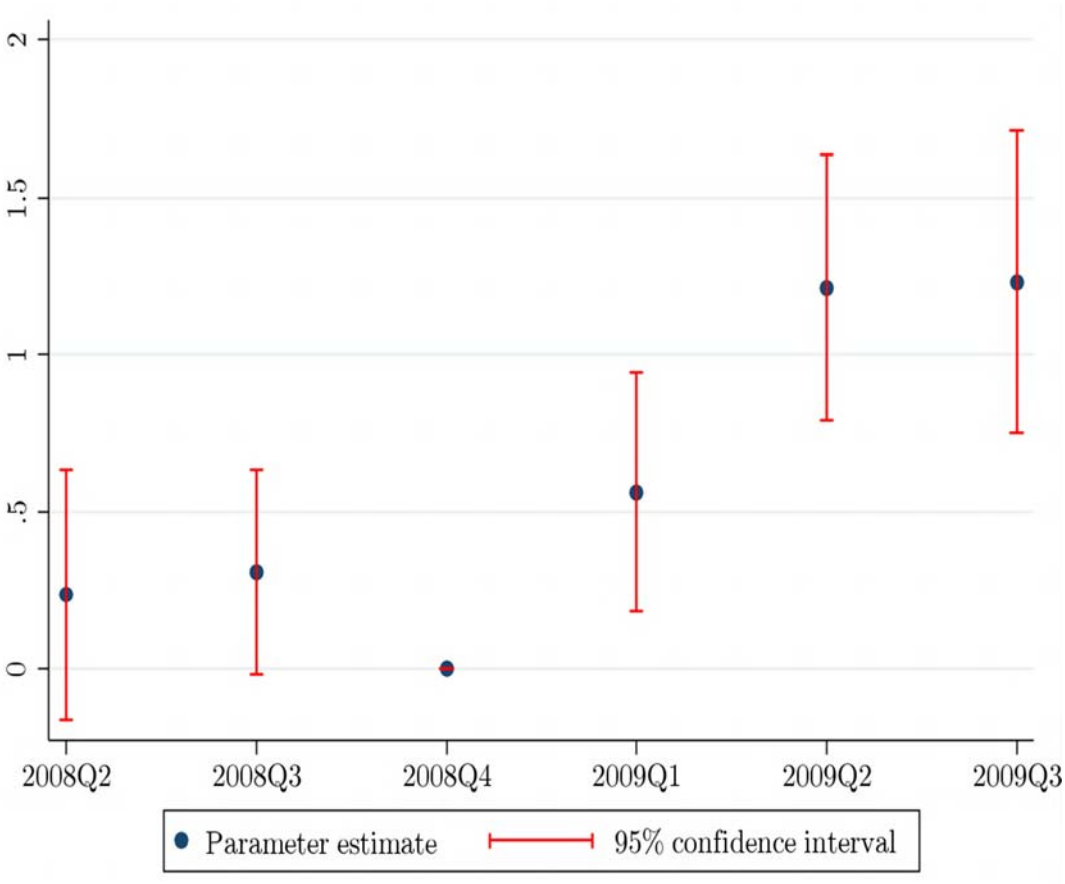
Notes: Figure plots all counties in the contiguous state. Darkly shaded areas indicate counties designated as high cost, defined as counties with conforming loan limits greater than $417,000.

Figure 10. Refinance Origination Count in Low-Cost Areas



Notes: Figure plots the count of refinance mortgage originations in low-cost areas recorded by LPS for loans below and above the GSE conforming loan limit (CLL). See notes for Figure 7.

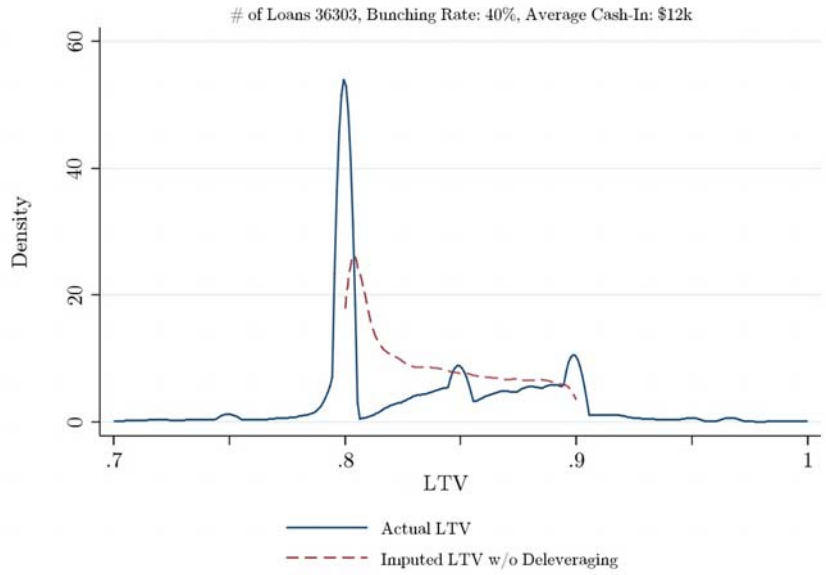
Figure 11. Event Study: The Effect of LSAPs on Bank Cash Holdings



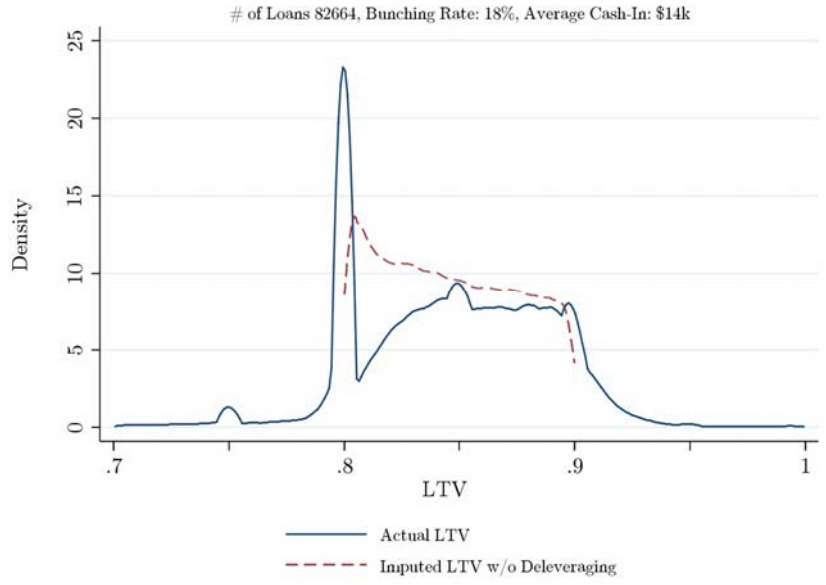
Notes: Figure plots coefficients on Fraction of Assets in Real Estate as of 2008 Q1 by Quarter from an event study regression in which the dependent variable is the log of cash holdings of each bank holding company in that quarter. The specification includes bank fixed effects and time fixed effects, and the coefficient of 2008 Q4 is normalized to zero. Standard errors are clustered at the bank-holding company and the 95 percent confidence intervals are reported.

Figure 12. Loan-to-Value Ratio Bunching Pre-HARP and Post-HARP

Panel I. Pre-HARP

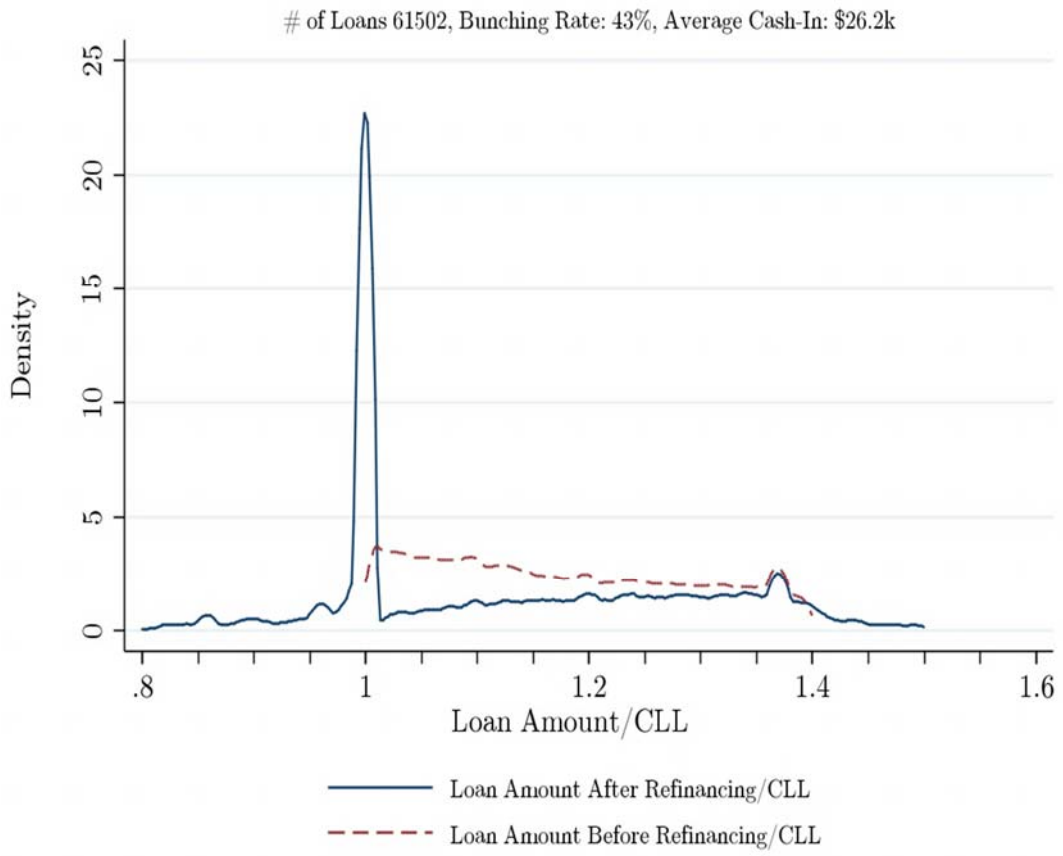


Panel II. Post-HARP



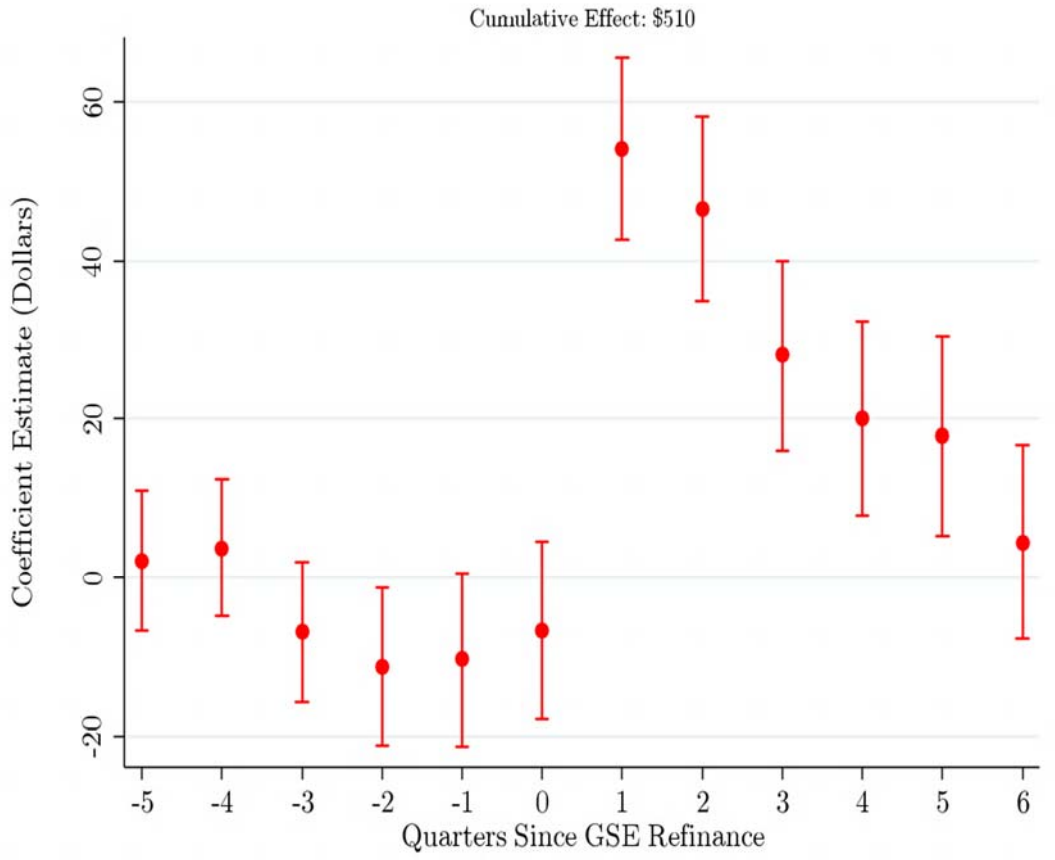
Notes: Figures report the distribution of borrower LTV ratios before and after refinancing for loans below the conforming loan limit originated during QE1 for which we observe the predecessor loan with imputed LTV above 80%. The dashed lines represent the imputed loan-to-value ratio distribution for mortgages that will be refinanced during the time period. To account for rolling closing costs into the balance of the new loan, we add average refinancing costs ($3,000) to the loan balance before the refinance. The solid blue lines report the distribution of actual LTV ratios for originated refinance mortgages. The bunching rate is the number of refinance mortgages with an 80% or lower LTV ratio at origination divided by the total number of loans with an LTV ratio exceeding 80% that refinance. Reported average cash-in is the average amount borrowers refinancing an above 80%-LTV ratio mortgage provide at the closing of their new refinance mortgage. Panel I plots the distribution of predecessor and refinance mortgages during QE1 but before the start of the Home Affordable Refinance Program (HARP) (Dec. 2008 to May 2009). Panel II plots these distributions after the introduction of HARP (June 2009 - Mar. 2010).

Figure 13. Conforming Loan Limit Bunching



Notes: Figure plots distribution of loan sizes relative to the local conforming loan limit (CLL). The dashed line plots the distribution of normalized loan sizes for those borrowers with loan sizes above the CLL who refinanced one quarter prior to refinancing. The solid line shows the distribution of normalized loan sizes for the refinance mortgages of the borrowers whose predecessor loans are represented by the dashed line. The sample consist of refinance loans originated during 2008-2013 for which we observe the predecessor loan with outstanding principal between 100 and 140% of the local CLL. We adjust for expected refinancing costs. See notes to Figure 12 for other details.

Figure 14. Consumption Response to Refinancing: Auto Expenditures



Notes: Figure plots the event study coefficient for households expenditure on automobiles and quarters after refinancing. Quarter one is the first quarter after the household refinances her mortgage. The sample consist of households who refinanced their mortgages during the QE1 as well as those who never refinanced. Controls include individual fixed effect, county-month fixed effects and origination cohort. Standard errors are clustered at the month level and 95% confidence intervals are reported.

Table 1. Federal Reserve Unconventional Monetary Policy Announcement Dates

Episode	Announcement Date
QE1.1	25-Nov-08
QE1.2	1-Dec-08
QE1.3	16-Dec-08
QE1.4	28-Jan-09
QE1.5	18-Mar-09
QE1.6	23-Sep-09
QE2.1	10-Aug-10
QE2.2	21-Sep-10
FG.1	9-Aug-11
FG.2	25-Jan-12
QE3.1	13-Sep-12
QE3.2	22-May-13
QE3.3	19-Jun-13
QE3.4	10-Jul-13
QE3.5	18-Sep-13

Note: Table reports the timing of Federal Reserve Quantitative Easing announcements from Krishnamurthy and Vissing-Jorgensen (2011).

Table 2. Effect of QE Campaign Beginning on Interest Rates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				Panel I. 3-month Window around QE start dates					
QE1 Indicator	-107.35***	-107.51***							
	(13.54)	(13.55)							
QE1 x Jumbo		48.56***	41.81***						
		(6.44)	(7.49)						
QE2 Indicator				-8.79	-8.71				
				(7.26)	(7.28)				
QE2 x Jumbo					-6.54	-9.09			
					(6.17)	(6.28)			
QE3 Indicator							-18.04**	-18.04**	
							(5.92)	(5.91)	
QE3 x Jumbo								-0.01	-1.02
								(1.51)	(1.74)
Jumbo Indicator	61.34***	29.95***	33.18***	42.56***	46.61***	47.62***	25.96***	25.96***	28.18***
	(10.24)	(5.47)	(5.52)	(3.47)	(3.91)	(3.89)	(0.74)	(1.13)	(1.26)
Observations	331,895	331,895	331,895	366,351	366,351	366,351	201,060	201,060	201,060
R-squared	0.56	0.56	0.67	0.12	0.12	0.24	0.22	0.22	0.34
				Panel II. 6-month Window around QE start dates					
QE1 Indicator	-128.27***	-128.51***							
	(9.43)	(9.44)							
QE1 x Jumbo		55.94***	52.78***						
		(6.52)	(5.84)						
QE2 Indicator				-9.89	-9.71				
				(12.48)	(12.54)				
QE2 x Jumbo					-13.13*	-14.30**			
					(7.27)	(6.07)			
QE3 Indicator							-32.59***	-32.48***	
							(5.84)	(5.83)	
QE3 x Jumbo								-3.33	-4.80
								(3.06)	(2.94)
Jumbo Indicator	53.07***	16.85**	20.15***	37.50***	45.56***	45.78***	23.36***	25.42***	27.58***
	(9.08)	(5.57)	(4.72)	(4.10)	(3.66)	(2.92)	(1.91)	(1.23)	(0.80)
Observations	789,945	789,945	789,945	549,484	549,484	549,484	438,201	438,201	438,201
R-squared	0.67	0.67	0.75	0.11	0.11	0.43	0.30	0.30	0.43
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County*Month FE	No	No	Yes	No	No	Yes	No	No	Yes

Notes: The table reports coefficients estimates of regressions relating the interest rates to the quantitative easing programs. The QE Indicators are equal to one after the introduction of each quantitative easing program. QE x Jumbo is the interaction between the dummies for the introduction of the programs and an indicator equal to one for the jumbo sector of the market. Columns (1)-(3) report the results for QE1, Columns (4)-(6) for QE2 and Columns (7)-(9) for QE3. Panel I shows the results for the three-month window, while Panel II reports the results for the six-month window. In Columns (3), (6) and (9) we control for county by month fixed effects. Standard errors are clustered at the month level, and are reported in parentheses.

Table 3. Effect of QE Campaign Beginning on Refinance Origination Volumes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				Panel I. 3-month Window around QE start dates					
QE1 Indicator	0.77***	0.77***							
	(0.01)	(0.01)							
QE1 x Jumbo	-0.78***	-0.75***	-0.98***						
	(0.05)	(0.04)	(0.15)						
QE2 Indicator				0.01	0.01*				
				(0.01)	(0.01)				
QE2 x Jumbo				0.26***	0.31***	0.29***			
				(0.04)	(0.03)	(0.10)			
QE3 Indicator							0.15***	0.15***	
							(0.01)	(0.01)	
QE3 x Jumbo							-0.02	-0.02	-0.00
							(0.04)	(0.03)	(0.09)
Jumbo Indicator	-1.95***		-1.94***	-2.56***		-2.61***	-1.89***		-1.97***
	(0.04)		(0.10)	(0.03)		(0.07)	(0.03)		(0.07)
Observations	16,328	16,328	16,328	18,255	18,255	18,255	17,212	17,212	17,212
R-squared	0.88	0.90	0.98	0.92	0.94	0.98	0.91	0.93	0.97
				Panel II. 6-month Window around QE start dates					
QE1 Indicator	0.83***	0.83***							
	(0.01)	(0.01)							
QE1 x Jumbo	-0.85***	-0.82***	-1.09***						
	(0.03)	(0.03)	(0.09)						
QE2 Indicator				-0.03***	-0.03***				
				(0.01)	(0.01)				
QE2 x Jumbo				0.30***	0.31***	0.34***			
				(0.03)	(0.02)	(0.07)			
QE3 Indicator							0.23***	0.23***	
							(0.01)	(0.01)	
QE3 x Jumbo							-0.05**	-0.07***	-0.10
							(0.03)	(0.02)	(0.06)
Jumbo Indicator	-1.92***		-1.92***	-2.32***		-2.43***	-1.92***		-1.97***
	(0.02)		(0.06)	(0.02)		(0.05)	(0.02)		(0.05)
Observations	33,781	33,781	33,781	35,391	35,391	35,391	34,872	34,872	34,872
R-squared	0.87	0.89	0.98	0.87	0.90	0.97	0.90	0.92	0.97
County FEs	Yes			Yes			Yes		
County*Jumbo FEs		Yes			Yes			Yes	
County*Month FEs			Yes			Yes			Yes

Notes: Table reports coefficients estimates of regressions relating the refinancing volume to the quantitative easing programs. The QE Indicators are equal to one after the introduction of each quantitative easing program. QE x Jumbo is the interaction between the dummies for the introduction of the programs and an indicator equal to one for the jumbo sector of the market. Columns (1)-(3) report the results for QE1, Columns (4)-(6) for QE2 and Columns (7)-(9) for QE3. Panel I shows the results for the three-month window, while Panel II reports the results for the six-month window. In Columns (3), (6) and (9) we control for county by month fixed effects. Standard errors are clustered at the month level, and are reported in parentheses. Asterisks denote significance levels (***=1%, **=5%, *=10%).

Table 4. Relationship between Liquidity Facility Borrowing and Bank Lending and Holdings

	(1) Total Loans Backed by RE / Total Assets_{2008}	(2) Total CI Loans / Total Assets_{2008}	(3) Securitized Loans / Total Assets_{2008}	(4) Cash Holdings / Total Assets_{2008}	(5) Total MBS / Total Assets_{2008}
Total Liquidity Facilities Borrowing / Total Assets_{2008}	0.27**	0.11*	0.17**	0.05	0.08**
	(0.12)	(0.06)	(0.07)	(0.04)	(0.04)
Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	1,159	1,159	1,201	1,201	1,159
R-squared	0.89	0.94	0.78	0.75	0.83

Notes: The table reports coefficients estimates of regressions relating the banks' lending and trading activities to the borrowing from the liquidity lending facilities. The main independent variable is the total amount borrowed by each bank holding company from the liquidity facilities, normalized by their total assets in the first quarter of 2008. In Column (1) the dependent variable is the ratio of total loans backed by real estate assets to total assets. Column (2) reports the results for commercial and industrial loans, while Column (3) investigates the effect on securitized loans. Column (4) related the liquidity facilities to the cash holdings. Column (5) investigates the effects on the total MBS holdings. All columns control for bank and quarter fixed effects. Standard errors are clustered at the bank level, and are reported in parentheses.

Table 5. Relationship between QE1 Exposure and Bank Lending

	(1)	(2)	(3)	(4)
		Real Estate		
	Cash	*Loans*	*CI Loans*	*MBS*
QE1 × Fraction RE	0.731***	-0.100***	-0.05	-0.01
Assets_{2008}	(0.18)	(0.03)	(0.05)	(0.12)
Bank Fixed Effects	Yes	Yes	Yes	Yes
Bank Controls	Yes	Yes	Yes	Yes
Observations	2,761	2,594	2,594	2,492
R-squared	0.18	0.04	0.01	0.01
Number of Banks	695	677	677	655

Notes: The table reports coefficients estimates of regressions relating the banks' lending and trading activities to the first quantitative easing program. The sample period is between the third quarter of 2008 and the second quarter of 2009. The main independent variable is the total amount of real estate assets held by each bank holding company, normalized by their total assets in the first quarter of 2008 and interacted with the QE1 Indicator, which is equal to one after the introduction of the first quantitative easing program. In Column (1) the dependent variable is the banks' cash holdings, while Column (2) and (3) report the results for the real estate and commercial and industrial loans. Column (4) investigates the effects on the banks' MBS holdings. In all specifications we control for bank fixed effects. Standard errors are clustered at the bank level, and are reported in parentheses.

Table 6. Relationship between QE3 Exposure and Bank Lending

	(1)	(2)	(3)	(4)
		Real Estate		
	Cash	*Loans*	*CI Loans*	*MBS*
QE3 × Fraction RE	0.145**	0.042***	0.047**	-0.04
Assets_{2012}	(0.06)	(0.01)	(0.02)	(0.04)
Bank Fixed Effects	Yes	Yes	Yes	Yes
Bank Controls	Yes	Yes	Yes	Yes
Observations	2,761	2,594	2,594	2,492
R-squared	0.18	0.04	0.01	0.01
Number of Banks	695	677	677	655

Notes: The table reports coefficients estimates of regressions relating the banks' lending and trading activities to the third quantitative easing program in 2012. The main independent variable is the total amount of real estate assets held by each bank holding company, normalized by their total assets in the first quarter of 2012 and interacted with the QE3 Indicator, which is equal to one after the introduction of the third quantitative easing program, i.e. third and fourth quarter of 2012. In Column (1) the dependent variable is the banks' cash holdings, while Column (2) and (3) report the results for the real estate and commercial and industrial loans. Column (4) investigates the effects on the banks' MBS holdings. In all specifications we control for bank fixed effects. Standard errors are clustered at the bank level, and are reported in parentheses.

Table 7. Effect of QE on Commercial Loan Size

	(1)	(2)	(3)	(4)
QE1 × Fraction RE Assets$_{2008}$	0.07	-0.13	0.14	0.28
	(0.27)	(0.35)	(0.34)	(0.21)
QE1 × Change in Market Cap			0.27*	0.32**
			(0.15)	(0.14)
QE1 × Fraction Deposits$_{2008}$				-0.71***
				(0.25)
Borrower Fixed Effects	Yes	No	No	No
Time Fixed Effects	Yes	No	No	No
Lender Fixed Effects	Yes	Yes	Yes	Yes
Borrower × Time FEs	No	Yes	Yes	Yes
Observations	1,813	1,813	1,813	1,813
R-squared	0.733	0.772	0.743	0.781

Notes: Table reports coefficients estimates of regressions relating the banks' lending activities to the first quantitative easing program. The dependent variable is the log loan amount of bank i to firm j at time t. The time period includes two quarters before and after the start of QE1. The loan-level data is from DealScan. The main independent variable is the real estate assets held by each bank holding company, normalized by their total assets in the first quarter of 2008 and interacted with the QE1 Indicator, which is equal to one after the introduction of the first quantitative easing program. Column (1) controls for borrowers fixed effects, quarter fixed effects and lender fixed effects. Columns (2)-(4) also control for borrower times quarter fixed effects. Columns (3) and (4) also include the interaction between the QE1 Indicator and the change in the banks' market capitalization and its interaction with the fraction of bank's deposit as of 2008. Standard errors are clustered at the bank level, and are reported in parentheses.