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Monetary stimulus and bank lending☆

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ABSTRACT

The US Federal Reserve purchased both agency mortgage-backed securities (MBS) and Treasury securities to conduct quantitative easing. Using micro-level data, we find that banks benefiting from MBS purchases increase mortgage origination, compared with other banks. At the same time, these banks reduce commercial lending and firms that borrow from these banks decrease investment. The effect of Treasury purchases is different: either positive or insignificant in most cases. Our results suggest that MBS purchases caused unintended real effects and that Treasury purchases did not cause a large positive stimulus to the economy through the bank lending channel.

1. Introduction

The 2008–2009 financial crisis and recession has led central banks to conduct unconventional monetary policy in continuous attempts to revive their economies. Quantitative easing (QE) was a prominent tool used in this spirit in the US, Japan, Europe, and elsewhere. With this tool, central banks purchase financial assets such as Treasuries or mortgage-backed securities (MBS), hoping to reduce yields, boost lending, and stimulate economic activities.

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Banks and their lending decisions are thought to play a key role in the transmission mechanism. A key question in academic and policy circles following the crisis and policy intervention is whether QE was successful in its stated goals. Some think that QE helped revive the economy and that the recession would have been much worse without it. Others think that QE could have had no effect. Others still consider the possibility that it had negative effects by inflating bubbles and distorting the allocation of resources.

Over the years, a large literature attempted to identify the impact of traditional monetary policy via the bank lending channel. While the effects of QE can be similar in some respects, meaningful distinctions also exist given the unprecedented magnitude of intervention and the nature of the tool. Like traditional monetary policy, identifying the effect of QE is difficult because changes that follow the intervention could be attributed to other changes in the economy around the same time. In this paper, we follow the logic of Kashyap and Stein (2000) and others by exploiting the heterogeneity across banks to assist with identification. The usual idea is that some banks are expected to be more affected by the policy than others, so their different actions following monetary policy shocks can speak to the causal effect of monetary policy.

This idea is sharpened in the context of QE. In the US, the Federal Reserve bought particular types of assets (specifically Treasuries and MBS) in varying quantities in multiple rounds of QE. Within the bank lending channel, the typical mechanism through which this policy is thought to have an effect is capital gains. The large-scale asset purchases (LSAPs) lower yields and increase prices of banks' current asset holdings, thereby improving the condition of their balance sheets and leading to more lending in multiple sectors. Fed officials often framed the impact of QE through these price effects (Yellen, 2012; Bernanke, 2012). Thus, one would expect that banks that held more of the purchased assets (Treasuries and MBS) and related securities benefited more from such asset purchases.

A less discussed but related mechanism within the bank lending channel is the origination channel in the specific context of MBS purchases. Banks that securitize mortgages into agency MBS are strongly affected by these asset purchases because these banks directly sell such products to the Federal Reserve as a part of QE. The Federal Reserve chose to implement the MBS purchases through the to-be-announced (TBA) market. In this market, the main parameters of the contract (coupon, maturity, issuer, settlement date, face value, and price) are agreed upon in advance. The exact pool of mortgages satisfying these terms is determined at settlement, which is typically one to three months in the future. As the TBA market primarily focuses on new mortgages, banks have a strong incentive to originate and securitize mortgages to fulfill these contracts. Existing legacy MBS or mortgage holdings on the banks' balance sheet will not be a candidate for selling to the Federal Reserve via these asset purchases.

We use two measures to capture the exposure of banks to these MBS purchases and the underlying mechanisms: (1) the amount of MBS holdings on the banks' balance sheet and (2) those high-MBS banks that actively securitize other assets. Ideally, we would disentangle banks that are exposed only to MBS-related capital gains from those that are also affected by the origination incentive. In practice, we cannot completely do so. While the banks that actively securitize assets and have high MBS holdings undoubtedly are strongly incentivized by the origination channel, many high-MBS banks could still be active originators without participating in securitization. Balance sheet data do not provide a way to separate these banks further. We can compare these banks with banks that are more exposed to Treasury purchases, as only a capital gains mechanism exists in that case. As a measure of exposure to Treasury purchases, we use the amount of Treasuries and other non-MBS securities on the banks' balance sheet.

To shed light on the effects of QE, we analyze the behavior of banks after rounds of asset purchases and compare it with that of banks that were expected to be less affected by these two components within the bank lending channel. Moreover, our richly detailed data enable us to track the effect from asset purchases, through the affected banks, to the firms that are connected to these banks. We thus can directly examine the real effects of QE. Given that firms are sometimes connected to different banks, this also allows for clean identification. We inspect the borrowing of a given firm from different banks that are differentially affected by QE. This approach removes any concerns that the effects could be driven by firms' demand for borrowing instead of banks' lending decisions.

Asset purchases in the US had three different rounds. In QE1 and QE3, the Federal Reserve bought MBS and Treasuries. In QE2, it bought primarily Treasuries. Although these three rounds were the impetus for much of the asset purchases, the Federal Reserve also made purchases between rounds of QE in response to maturing securities and to maintain the size of its balance sheet. The Maturity Extension Program (MEP) consisted of buying long-maturity Treasuries and selling short-maturity Treasuries. This program occurred between QE2 and QE3.

We start by investigating the patterns in bank mortgage lending following MBS purchases by the Federal Reserve. In this case, both capital gains and origination components of the bank lending channel have effects in the same direction. We show, as expected, that banks that were more exposed to the MBS market increased their mortgage lending following MBS purchases more than the less exposed banks. For every dollar of MBS purchased, these banks loaned 3.63 cents more in terms of mortgages. For the total purchase of approximately $1.75 trillion worth of MBS, this suggests additional lending of $63.53 billion. This is a reassuring confirmation that QE had a direct, positive effect. As intended, the Federal Reserve improved the attractiveness of mortgage lending, inducing banks exposed to this market to increase their activity in it.

More surprisingly, we show that the more exposed banks slowed their commercial and industrial (C&I) lending following these MBS purchases. Hence, there seems to be a negative indirect effect, which amounts to the crowding out of other types of loans not directly targeted by the MBS purchases in QE. As QE1 and QE3 focused on the housing market by purchasing large amounts of MBS assets, they encouraged exposed banks to lend more in this market. This came at the expense of other types of lending,

such as C&I lending for those affected banks. The magnitude of this crowding out is large. For every dollar of additional MBS purchases under QE, we estimate a reduction of 1.22 cents in C&I lending. Scaled in terms of additional mortgage lending stimulated by QE, this is a 34 cent reduction in commercial lending for each dollar of additional mortgage lending. The mechanism is likely a result of a substitution effect. While banks benefit from capital gains, the origination component dominates, and good opportunities for banks in one line of business (mortgages) shift resources away from other lines of business (C&I loans). While such crowding out likely took place in other markets as well (e.g., consumer credit), this paper focuses on C&I lending. Consistent with this argument, we find a larger effect for the more financially constrained banks within this group. This reduction is strongest in the period through QE1, when the banking sector as a whole was most constrained. We find, in line with a crowding-out effect, that the profitability of those commercial loans being extended by the exposed banks increases in response to MBS purchases. The logic behind the crowding-out behavior resembles that featured in the internal capital markets literature (e.g., Stein, 1997; Scharfstein and Stein, 2000), in which constrained firms are expected to shift resources across divisions to respond to the most attractive investment opportunities.

Investigating further the implications of the crowding-out behavior following MBS purchases, we use DealScan and Compustat data to trace the behavior of firms connected to affected banks. We demonstrate the real effect of crowding out of C&I loans by banks affected by MBS purchases. Firms that have relationships with these banks had to cut their investment following these rounds of QE. For every dollar of additional mortgage lending stimulated through MBS purchases, firms reduce investment by 12 cents. As expected, this behavior is observed mostly for more financially constrained firms. In interpreting these results, one could be concerned that the decrease in C&I loan growth and investment reflects a decrease in demand from firms instead of a decrease in supply from banks. We address this issue in several ways. Most notably, we conduct an analysis for firms that borrow from multiple banks, some of which are strongly affected by MBS purchases and some of which are not. We show that, after controlling for firm-time fixed effects, a given firm saw a decrease in loan size from affected banks relative to the loan size from non-affected banks. We also do not find evidence that firms are able to obtain sufficient substitute capital from other sources of financing such as equity markets or nonbank sources of debt.

While MBS purchases increased mortgage origination and decreased C&I lending for affected banks, Treasury purchases did not have a negative effect on C&I lending or firm investment. This is important because, in the case of Treasuries, only the capital gains mechanism is at work. The relatively insignificant real effects of Treasury purchases suggest that the capital gains mechanism is relatively weak compared with the origination mechanism.

Overall, our paper demonstrates that the type of asset being purchased is very important in designing QE. Through its choice of assets purchased, beyond providing overall stimulus, the Federal Reserve directly affected credit allocation within the economy. The unintended negative consequences of MBS purchases on C&I lending and, ultimately, firm investment are due to the less-discussed origination mechanism. This general message has broader implications, given that other countries have experimented with purchases of other assets. The European Central Bank has been purchasing corporate debt and the Japanese Central Bank has purchased equities. It would be interesting to investigate their differential effects as well.

Our results contribute to the debate about which channels were most salient for the transmission of QE. Krishnamurthy and Vissing-Jørgensen (2013), for example, discuss several channels through which QE could have had a role. Our paper shows that the incentive of banks to originate mortgages (the origination channel) is particularly important. It appears to dominate any positive spillovers from the capital gains channel in markets, such as commercial lending, where the effects are opposite in direction. In general, the capital gains channel, whether for MBS or Treasury securities, appears to be relatively weak.

A small literature recently has emerged on QE and bank lending. The closest paper to ours is Rodnyansky and Darmouni (2017). They also exploit heterogeneity at the bank level due to differences in holdings of MBS to investigate the effect of QE on bank lending. Their main focus is on mortgage lending. While C&I lending is not central in their paper, their analysis does touch on it and does not uncover the crowding-out effect that MBS purchases had on the C&I lending of exposed banks, which we show here. This is because of key differences in the research design. Rodnyansky and Darmouni (2017) utilize the timing of QE rounds as the only source of exogenous variation by using three time dummies for the QEs. In other words, they compare lending patterns before and after the three QE rounds, effectively assuming that the only aggregate variation during and after the financial crisis was the introduction of the three QE episodes. This leads to the commingling of the effect of a QE round with that of any policy or aggregate variation that coincides with that timing. For example, the Federal Reserve also maintained extremely low interest rates during the entire period. Further, because Rodnyansky and Darmouni (2017) do not separate the effects of Treasury and MBS purchases, the stimulus effects of these two types of asset purchases are also commingled. In contrast to time dummies for the QEs, we use quarter-by-quarter observations of monetary stimulus so that we can control for unobserved aggregate economic conditions and changing regulatory policy during the period by including quarter fixed effects. In addition, we explicitly use the amount of MBS purchases and the amount of Treasury purchases by the Federal Reserve in every quarter as the direct measure of monetary stimulus and its intensity.[1] These two differences in our research design allow us to tease out the effects of monetary shocks from other confounding policy changes and economic conditions. We find that MBS purchases crowded

[1] See, for example, Morais et al. (2019), who use the amounts of assets purchased to measure the effects of QE.

out C&I lending, while Treasury purchases led to a potential increase in C&I lending. Rodnyansky and Darmouni (2017) could be picking up the effect of Treasury purchases in their results. Finally, a fundamental difference between our papers is that we explore the truly real effects of QE by considering firms' investments and bank-firm–specific lending relationships, whereas Rodnyansky and Darmouni (2017) only look at banks' general lending patterns.

In addition to Rodnyansky and Darmouni (2017), two other contemporary papers investigate separate aspects of QE and bank lending and complement our findings. Di Maggio et al. (2016) examine how unconventional monetary policy affected the volume of new mortgages issued. They find that financial institutions originated more mortgages of the type that were eligible for purchase by the Federal Reserve, which led to additional mortgage refinancing and consumption. Kandrac and Schulsche (2016) find that bank reserves created by the Federal Reserve led to higher total loan growth and more risk taking within banks' loan portfolios. Evidence also exists that some firms, depending on their capital structure, could have obtained advantageous financing due to QE. Foley-Fisher et al. (2016) find that the Maturity Extension Program allowed firms dependent on long-term debt to issue more such debt as well as expand employment and investment.

Outside the recent QE literature, our paper relates to the broader literature that explores the impact of traditional monetary policy on the economy through the bank lending channel. This literature shows that shocks to financial institutions affect their ability to lend and end up impacting the firms that borrow from them (Bernanke, 1983; Stein, 1998; Kashyap and Stein, 2000). The impact of monetary policy on firms assumes that banks and firms are financially constrained to some extent (this literature also includes Kashyap and Stein, 1995; Peek and Rosengren, 1995; Holmstrom and Tirole, 1997; Bolton and Freixas, 2006, among others), which is a basic premise of our paper as well. The phenomenon of the crowding out of bank lending from one sector of the economy by another sector is related to the theory in Farhi and Tirole (2012) and the empirical evidence in Chakraborty et al. (2018). Chakraborty et al. (2018) find that during the US housing boom, banks in stronger housing markets reduced commercial lending in favor of more mortgage activity, and firms that borrowed from these banks had to reduce investment as a result. Our paper shows that after the boom ended, a different phenomenon crowds out capital from firms. That is, MBS purchases in quantitative easing led benefiting banks to increase real estate lending and reduce C&I lending.

Finally, our paper ties into a far more general literature on the effects of monetary stimulus on the economy.[2] A recent part of this literature investigates the connection between lower interest rates and bank activity (e.g., Maddaloni and Peydró, 2011; Jiménez et al., 2014; Dell'Ariccia et al., 2014), negative interest rates and bank risk (Heider et al., 2019), and pass-through to consumer credit (Di Maggio et al., 2017; Agarwal et al., 2018). Another related strand looks at the effects of QE on asset prices (e.g., Krishnamurthy and Vissing-Jørgensen, 2011; 2013; Bekaert et al., 2013; Hanson and Stein, 2015).

The paper is organized as follows. Section 2 describes the data used for the analysis and how we determine bank exposure to asset purchases. Section 3 reports the effects of asset purchases on mortgage lending, firm-level loan activity, and overall bank commercial lending. Section 4 investigates the effects of asset purchases on firm investment and firm financing in general. Section 5 discusses potential endogeneity concerns and our methods to address them. Section 6 provides additional evidence in support of the crowding-out effect. Section 7 explores additional effects during the QE period. Section 8 concludes.

2. Data

This paper considers the effect of asset purchases on the mortgage origination and commercial lending activity of banks and how changes in bank activity affect lending to firms and their real activity. We combine mortgage origination data from the Home Mortgage Disclosure Act (HMDA) with bank commercial lending data from Call Report. We also use the Call Report data for other information about the bank's balance sheet and to measure its exposure to asset purchases. We supplement these data with information on bank mortgage rates from RateWatch. To establish firm-bank relationships and consider lending to specific firms, we use DealScan data combined with Compustat data for additional firm information. Our asset purchase data come from the Federal Reserve Bank of New York. Given our focus on asset purchases made by the Federal Reserve, we consider the period from the fourth quarter of 2005 through the fourth quarter of 2013.[3] Section 2.1 covers the Federal Reserve's asset purchase programs in more detail. As our identification strategy utilizes the differential impact of these asset purchases based on bank exposure to them, Section 2.2 discusses some features of the agency MBS market and how we measure bank exposure. Section 2.3 examines the bank data, and Section 2.4 explains how we determine firm-bank lending relationships, along with the relevant firm and loan data.

2.1. Federal reserve asset purchases

Critical to our analysis are the amounts of MBS and Treasury securities purchased by the Federal Reserve Bank of New York under its permanent open market operations. Historical data for these Treasury purchases begin in August 2005. In November 2008, the Federal Reserve announced a plan to purchase up to $100 billion in direct obligations of government-sponsored enterprises (GSEs) or government-owned enterprises (GOEs) and up to $500

[2] Another strand of literature investigates the effects of post-crisis fiscal and regulatory policies on bank lending and the economy (e.g., Duchin and Sosyura, 2014; Chakraborty et al., 2017; Becker and Ivashina, 2018).

[3] The third quarter of 2005 is the first quarter with any asset purchase data, and the fourth quarter of 2013 is the most recent quarter for which all our data sources can be matched.

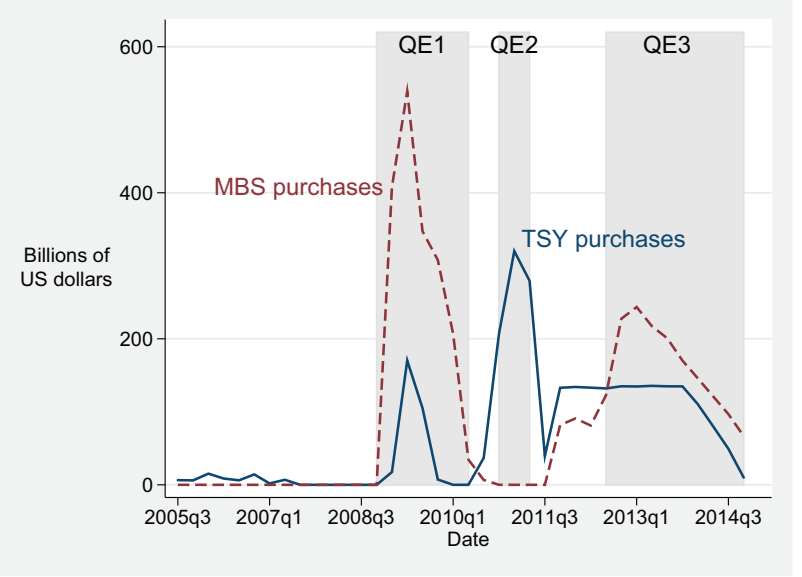

Fig. 1. Quarterly totals of Treasury (TSY) and mortgage-backed security (MBS) purchases by the Federal Reserve. The MBS purchases include direct government-sponsored enterprise and government-owned enterprise obligations purchased in 2008. QE1, QE2, and QE3 denote the first, second, and third round of quantitative easing, respectively. Source: Federal Reserve Bank of New York.

billion in MBS purchases, which started in early 2009.[4] In March 2009, the program expanded with an additional $750 billion in agency MBS purchases and $300 billion in Treasury purchases, and it continued until June 2010. This initial round of purchases became known as QE1.

In November 2010, the Fed announced a second round of purchases (QE2), totaling up to $600 billion in Treasury purchases, which concluded in June 2011. The third round of quantitative easing (QE3), ran from September 2012 through October 2014, initially at purchase rates of $40 billion per month for agency MBS and $45 billion per month for Treasury securities. The total increase to the Fed's balance sheet after the completion of three rounds of QE was about $1.75 trillion in MBS holdings and $1.68 trillion in Treasury holdings.

While the net and gross purchases yield similar empirical results, we use gross purchases as a measure of the amount of assets purchased each quarter. Using gross purchases allows us to capture the Maturity Extension Program, when the Federal Reserve purchased long-term Treasuries and sold short-term Treasuries to reduce long-term bond yields, as part of the treatment. Fig. 1 presents the total purchases by the open market operations desk on a quarterly basis. Over this window, some periods have predominantly MBS purchases (e.g., 2008q4 through 2009q3), Treasury purchases (e.g., 2010q3 through 2011q3), and a mix of both security types (e.g., 2012q1 through 2012q4).[5]

[4] The Federal Reserve made purchases of GSE and GOE obligations in September and December 2008. We include these purchases in our broader MBS category, but our results are similar if we exclude them from our analysis.

[5] In our analysis, we use the log of the dollar amount of MBS or Treasuries purchased in a quarter in millions. Quarters without purchases take on a zero value.

2.2. Bank exposure to the MBS and Treasury markets

The agency MBS market is composed of two distinct markets: a specified pool (SP) market, where specific MBS are traded, and a to-be-announced market. In the TBA market, the buyer and seller agree on six parameters of the contract: coupon, maturity, issuer, settlement date, face value, and price. The exact pool of mortgages that fits these parameters is determined at settlement, which is typically one to three months in the future (Gao et al., 2017). The majority of agency MBS purchases undertaken by the Federal Reserve occurred in the TBA market, and the Fed mainly bought 15-year and 30-year MBS at coupons close to current mortgage rates.

Banks have two avenues to transform mortgages into agency MBS: (1) sell the loans individually to the government agency for cash, which the agency can include in an MBS pool, or (2) organize their mortgages into a MBS pool and have the GSE or GOE certify it as an agency MBS. The second method, referred to as a swap transaction, requires the bank to have an additional pool purchase contract with the agency. These swapped MBS remain on the bank's own balance sheet as MBS assets until they are sold or mature.

An important point of differentiation among banks is their level of involvement in the secondary mortgage market. We try to capture this in two ways. The first is a measure of how much of the bank's total assets are MBS. Because MBS holdings arise, in part, as an intermediate step in these swap transactions, banks holding more MBS are more likely to be active in the secondary market. In our analysis, we treat the top tercile of banks by MBS holdings as most exposed to the secondary mortgage market and the bottom tercile of banks by MBS holdings as least exposed. The second variable we use to capture secondary market involvement is a refinement of our MBS holdings

variable. We focus on the subset of top tercile MBS banks that report nonzero net securitization income (denoted as *Securitizers*).[6] Those banks that not only engage in transactions with GSEs and GOEs but also securitize other nonagency loans are more likely to be involved in the secondary mortgage market. Whereas more than 80% of our bank observations report some MBS holdings on their balance sheets, only 3% of banks in our sample report nonzero securitization income at some point.

Although not our central focus, we construct a similar exposure variable for Treasury purchases. Unlike MBS, banks do not originate new Treasury securities. However, changes in Treasury yields driven by Federal Reserve purchases can affect banks through changes in the value of their own Treasury holdings or related securities. Given the central role of Treasuries in determining the value of many securities, we separate banks into terciles by the amount of non-MBS securities held.[7] Those banks that are in the highest tercile of securities holdings are likely to be more affected by Treasury purchases than banks in the lowest tercile of securities holdings through this capital gains channel.

2.3. Bank mortgage origination and commercial lending activity

The Federal Reserve conducted its MBS purchases through the TBA market, mainly at 15-year and 30-year maturities and coupons close to current mortgage rates. Such purchases incentivize banks to originate new conforming mortgages that can be packaged and sold in the TBA market. To capture banks' mortgage origination activity, we incorporate data from HMDA. We use the origination data, available on an annual basis, from 2005 to 2013. We calculate the annual mortgage origination growth for each bank, at the holding company level. We use these data as opposed to relying on the bank's balance sheet data because they capture both the mortgages that remain on the bank's balance sheet and those that are sold to other parties. Given the manner in which QE was undertaken, banks most affected by the MBS purchases should be actively selling mortgages or packaging mortgages into agency MBS and subsequently selling them to the Federal Reserve. Disentangling the new origination activity from the subsequent MBS conversions and sales is difficult if considering only the amount of unsecured real estate loans on the bank's balance sheet. Summary statistics are included in Panel A of Table 1.

In addition to national mortgage origination growth, we use the bank's state-level market share in some analyses. Using RateWatch data, we calculate the bank's average state-level mortgage rate for both 15-year and 30-year fixed rate mortgages. These mortgage rates are calculated at a quarterly frequency.

We use Call Report data to construct our measure of commercial and industrial loan growth, C&I loan profitability, the exposure measures discussed in Section 2.2, and our other bank-level control variables. These variables include the bank's size, equity ratio, net income, and cost of deposits. Acharya and Mora (2015) show that some banks experienced sizable liquidity shocks during the financial crisis. Hence, we also include loans to deposits and cash to assets as bank controls to absorb differences in liquidity. We calculate the unemployment rate across each bank's counties of operation using county-level unemployment rate data. We weight the unemployment rates by the fraction of total deposits of a bank in each county. We then utilize the change in this unemployment rate as an additional control. We use the bank's amount of demand deposits as a measure of constraints. The summary statistics for these variables are presented in Panel A of Table 1 and specific variable definitions can be found in Table A.1 in the Online Appendix.

2.4. Banks and commercial lending relationships

An important component of our analysis is the effect of the asset purchases on firm real activity through the bank lending channel. We determine firm-bank relationships using loan-level data from DealScan with firm-level data from Compustat.[8] The duration of the relationship is defined as follows. It begins in the first quarter that we observe a loan being originated between the firm and bank, and it ends when the last loan observed between the firm and bank matures, according to the original loan terms. Following Chakraborty et al. (2018), we use a link table that matches DealScan lenders to their bank holding companies in the Call Report data. In our sample period, we match 555 DealScan lenders to 138 bank holding companies in the Call Report data. These matches are determined by using the FDIC's Summary of Deposits data and other available data of historical bank holding company (BHC) structures. Throughout our analysis, all bank activity is investigated at the holding company level, so we refer to BHCs as "banks" for simplicity. Panel B of Table 1 provides statistics on the duration and number of relationships. Additional details on how relationships are determined and on the loan terms are provided in Online Appendix A.

We also use DealScan for loan amounts, to calculate loan growth at a firm-bank level, and for other contract terms. From Compustat, we use several firm-specific variables in our analysis. For our investment regressions, we

[6] To ensure that we are correctly identifying banks that are large and active enough to participate in the secondary mortgage market, we require the bank to have at least $100 million in assets and a 0.2 basis point share of the national mortgage origination market. Our results are similar if we omit these additional filters.

[7] Non-MBS securities include Treasury securities, other US government agency or sponsored-agency securities, securities issued by states and other US political subdivisions, other asset-backed securities (ABS), other debt securities, and investments in mutual funds and other equity securities. While the average bank in our sample holds 14.4% of assets in these non-MBS securities, 8.2% of assets on average are held in just Treasury and other US government securities (see Table 1). A possible argument is that Treasury purchases have a larger effect on government securities compared with other asset classes. Hence, as an alternative measure of securities holdings, in Online Appendix Section C.1, we restrict securities holdings to Treasury and other US government securities and find similar results.

[8] We link borrowers from DealScan to Compustat data using the link file from Chava and Roberts (2008).

Table 1
Summary statistics.
This table presents the summary statistics of the merged sample of bank holding companies and borrowing firms as obtained from Call Report, Home Mortgage Disclosure Act, DealScan, Compustat, and RateWatch databases. Our sample period runs from 2005q4 through 2013q4. All variables are at a quarterly frequency, with the exception of the mortgage origination and market share variables, which are at an annual frequency. The variable definitions are provided in Online Appendix Table A.1. "bps" refers to basis points.

Variable	Mean	Standard deviation	25th percentile	Median	75th percentile	Number of observations
Panel A: Bank variable and asset purchase statistics						
Bank variables						
MBS Holdings (percent)	7.07	8.35	0.22	4.09	10.9	155,573
Securities Holdings (percent)	14.4	11.5	5.72	11.8	20.4	155,573
US Government Securities Holdings (percent)	8.18	8.89	1.67	5.41	11.6	155,573
C&I Loan Growth (percent)	1.43	13.4	−4.90	0.28	6.24	155,573
Change in C&I Loan Profitability (percent)	−0.90	26.9	−11.6	−0.73	9.94	155,573
Bank's Size	12.2	1.36	11.3	12.1	12.9	155,573
Bank's Equity Ratio (percent)	10.3	2.74	8.60	9.83	11.5	155,573
Bank's Net Income (percent)	0.48	0.69	0.20	0.46	0.84	155,573
Bank's Cost of Deposits (percent)	1.06	0.83	0.42	0.80	1.54	155,573
Bank's Cash to Assets (percent)	6.73	6.22	2.64	4.37	8.48	155,573
Bank's Loans to Deposits (percent)	77.4	18.9	65.3	78.9	90.8	155,573
Bank's Demand Deposits (percent)	12.0	7.03	6.85	11.0	15.6	155,573
Securitizer	0.0077	0.088	0	0	0	155,573
Change in Unemp. Rate, Bank's Counties	0.073	1.33	−0.80	−0.10	0.81	155,573
Mortgage Origination Growth (percent)	23.3	80.8	−23.2	3.20	42.9	21,882
State-Level Mortgage Orig. Market Share (bps)	26.0	123.1	0.16	0.98	6.42	68,951
Average 30-year Rate (bps)	565.9	106.2	483.3	595.8	650	7,970
Average 15-year Rate (bps)	548.6	141.4	437.5	580.1	637.5	11,605
Monetary policy variables						
TSY Purchases (billions of US dollars)	70.3	88.0	1.88	15.3	134.0	33
MBS Purchases (billions of US dollars)	95.3	142.8	0	6.65	200.8	33
Rate Stimulus (percent)	3.34	1.23	2.58	3.64	4.41	33
Panel B: Relationship, loan, and firm variable statistics						
Relationship characteristics						
Bank Holding Companies per Borrower	1.59	0.91	1	1	2	4,361
Duration of Relationship (years)	6.86	4.29	4.75	5	8.50	6,925
Number of Loan Facilities	2.86	2.70	1	2	3	8,674
Loan characteristics						
Loan Amount (percent)	18.4	19.0	5.82	12.1	24.9	6,568
All In Drawn Spread (bps)	192.5	136.8	100	175	250	6,568
Maturity (months)	51.7	19.6	38	60	60	6,568
Takeover Loan (indicator)	0.18	0.39	0	0	0	6,568
Revolving Credit Line (indicator)	0.70	0.46	0	1	1	6,568
Term Loan (indicator)	0.26	0.44	0	0	1	6,568
Firm Loan Growth (percent)	3.26	23.0	−7.19	3.34	16.5	2,867
Firm variables						
Investment (percent)	2.82	2.89	1.26	2.07	3.40	64,070
Change in Debt (percent)	0.63	5.29	−0.98	−0.0030	0.95	64,070
Change in Equity (percent)	0.67	6.41	−0.025	0.082	0.39	64,070
Cash Flow	0.058	0.12	0.019	0.041	0.085	64,070
Lagged Tobin's q	3.08	5.11	0.63	1.35	3.32	64,070
Lagged Z-Score	0.58	1.41	0.26	0.74	1.20	64,070
Lagged Firm Size	7.45	1.74	6.28	7.43	8.60	64,070
Lagged Market-to-Book	1.65	0.88	1.12	1.41	1.89	64,070
Lagged Profitability (percent)	3.35	2.48	2.11	3.22	4.55	64,070
Lagged Tangibility (percent)	31.8	24.6	12.0	24.1	47.7	64,070

use Tobin's q, cash flow, firm size, and Altman's Z-score. For our analysis of changes in firm's debt and equity, we use market-to-book ratio, profitability, and tangibility in addition to firm size.[9] As we focus on how financial intermediaries affect borrowing firms' investment and financing decisions, we exclude any borrowing firms that are

[9] All firm and bank variables that are ratios are winsorized at the 1 and 99 percentiles. We deflate investment, Tobin's q, and cash flow by lagged quarterly gross property, plant, and equipment (PP&E) (Erickson and Whited, 2012). As gross PP&E is not available every quarter, we impute the missing values using a perpetual inventory identity.

financial companies. Panel B of Table 1 includes the summary statistics for our loan and firm variables.

3. Bank lending and QE

This section presents our first findings, that is, while QE asset purchases stimulated mortgage lending as intended, they also led banks to reduce their credit supply to firms. Section 3.1 investigates the impact of asset purchases on bank lending in the mortgage market. Sections 3.2 and 3.3 consider how asset purchases affected commercial lending at the firm and bank level, respectively. Section 3.4 discusses our bank lending results in the context of the findings in Rodnyansky and Darmouni (2017).

3.1. Mortgage lending and asset purchases

The Federal Reserve attempted to stimulate new mortgage activity through MBS purchases in the TBA market. In our analysis, we focus on the growth in banks' overall mortgage originations, not just the mortgage holdings that remain on banks' balance sheets. This choice is motivated by this origination channel component of QE: Banks are incentivized to originate new mortgages, package them as agency MBS, and sell them to the Federal Reserve in the TBA market.

We investigate the mortgage origination growth rate of banks in a specific year in response to MBS purchases, depending on the bank's exposure to the MBS market. Our first measure of a bank's exposure is based on the bank's MBS holdings as a fraction of assets. Banks in the top tercile of MBS holdings are considered more exposed and are compared with banks in the lowest tercile of MBS holdings. The second measure refines the first measure and classifies the subset of high-MBS banks that securitize assets as the most exposed. We include year and bank fixed effects to ensure that aggregate conditions and bank-specific time-invariant characteristics are not driving the changes in origination activity. The specification for bank j in year t is

$$\begin{aligned} &\textit{Mortgage Origination Growth Rate}_{jt} \\ &= \alpha_j + \gamma_t + \beta_1 \textit{MBS Purchases}_{t-1} + \beta_2 \textit{Bank Exposure}_{jt-1} \\ &\quad + \beta_3 \textit{Bank Exposure}_{jt-1} \times \textit{MBS Purchases}_{t-1} \\ &\quad + \beta_4 \textit{Bank Variables}_{jt-1} + \epsilon_{jt}. \end{aligned} \tag{1}$$

In this specification, as we are looking at the annual growth rate of mortgages, all lagged variables $(t-1)$ are from the fourth quarter of the prior year. We focus on β_3, the interaction of the amount of asset purchases with the exposure of the bank to the MBS market.[10] Throughout our analyses, we use the logarithm of the dollar amount of the purchases. Because we include year fixed effects, the coefficient for the MBS asset purchases (β_1) is absorbed. All specifications contain the following bank-level characteristics: size (excluding loans because the dependent variable is based on loan activity), equity ratio, net income, cost of deposits, loans to deposits, and cash to assets. These variables capture differences in the scale and financial position of banks that could affect lending activity.[11] We include the change in unemployment rate across a bank's counties of operation based on its deposits, as a measure of local economic conditions faced by the bank.

Table 2 reports the results. Because the growth rate is scaled by one hundred, Column 1 shows that a 1% increase in MBS purchases increases mortgage origination by about 0.95 basis points (bps). This increase is for the more exposed (high-MBS) banks compared with the less exposed (low-MBS) banks, and the inclusion of year fixed effects removes any other factors that could affect origination activity. A different concern is that banks with high MBS holdings can have other characteristics that drive the response of the banks in terms of mortgage origination. In other words, it is not MBS holdings but, for example, banks with high net income that respond more to the incentives provided by the Federal Reserve through MBS purchases. To address this concern, we next refine our approach of grouping banks based on MBS holdings. We estimate the amount of MBS holdings that can be explained by other bank characteristics (size, equity ratio, net income, cost of deposits, loans to deposits, and cash to assets) and then calculate the residual MBS holdings for each bank. This term is thus the bank's MBS holdings orthogonalized to other bank characteristics. We then refine the terciles of banks by MBS holdings, using the orthogonalized MBS holdings. Column 2 reports the results. The coefficient point estimate drops by 39%, but the result remains statistically and economically significant. Banks with higher MBS holdings lend more in response to MBS purchases.

Because the mechanism is that MBS asset purchases by the Federal Reserve in the TBA market encourage mortgage lending, we next use our second measure of the exposure of banks to MBS purchases to test the mechanism more directly. Column 3 focuses on the mortgage lending growth rate for high-MBS securitizer banks following MBS asset purchases. We maintain the same sample to compare securitizers with non-securitizers as in Columns 1 and 2. Comparing Column 3 with Column 1, we find that the effects are nearly twice as strong in this case. A 1% increase in MBS purchases leads to an increase of about 1.87 bps in mortgage lending growth for the high-MBS securitizer banks. As a back-of-the-envelope calculation, we determine that for an additional dollar of MBS purchases by the Federal Reserve, high-MBS securitizer banks provide an additional 3.63 cents in mortgage lending. For the $1.75 trillion increase in the Fed's balance sheet from MBS purchases over the QE period, we estimate approximately $63.53 billion in additional mortgage lending from these banks. (The details of these calculations are provided in Online Appendix B.) Thus, in response to MBS asset purchases, ben-

[10] Because we use bank fixed effects in our specifications, the coefficient for bank exposure as a stand-alone variable (β_2) is not economically meaningful. Not many banks switch between the high and low classifications of the exposure measures.

[11] See, e.g., Gatev et al. (2009), Ivashina and Scharfstein (2010), Cornett et al. (2011), and Berger and Bouwman (2013).

Table 2
Mortgage origination growth.

Columns 1 through 3 are panel fixed effect regressions. *Mortgage Origination Growth* is the annual mortgage origination growth rate for each bank, scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *MBS Purchases* is the quarterly log-dollar amount of gross Federal Reserve MBS purchases from the fourth quarter of the prior year. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Orthogonalized MBS holdings" refers to whether the MBS terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Mortgage Origination Growth		
Variable	(1)	(2)	(3)
High MBS Holdings	−8.904*	−5.690	
	(4.557)	(5.386)	
High MBS Holdings × MBS Purchases	0.953***	0.580**	
	(0.247)	(0.288)	
Securitizer			−18.75
			(19.05)
Securitizer × MBS Purchases			1.865**
			(0.842)
Bank's Size	−2.494	0.241	−2.523
	(6.189)	(6.886)	(6.213)
Bank's Equity Ratio	4.296***	4.210***	4.348***
	(0.811)	(0.904)	(0.813)
Bank's Net Income	1.464	1.803	1.607
	(1.580)	(1.882)	(1.580)
Bank's Cost of Deposits	−6.254*	−4.470	−6.269*
	(3.265)	(3.868)	(3.274)
Bank's Cash to Assets	0.680**	0.855**	0.606**
	(0.270)	(0.365)	(0.270)
Bank's Loans to Deposits	−1.301***	−1.405***	−1.302***
	(0.130)	(0.148)	(0.127)
Change in Unemp. Rate, Bank's Counties	1.933*	0.933	1.957*
	(1.116)	(1.175)	(1.118)
Orthogonalized MBS holdings	No	Yes	No
Bank fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Number of observations	14,237	10,562	14,237
Adjusted R^2	0.0821	0.126	0.0811

efiting banks engaged in more mortgage lending. This evidence shows that the mortgage origination channel is significant for the transmission of QE.

3.2. Unintended effects of asset purchases on firm lending

We next discuss the effect of asset purchases by the Federal Reserve on commercial and industrial lending. The argument as to why MBS purchases can crowd out C&I lending is as follows. To implement quantitative easing, the Federal Reserve announced its intention to purchase MBS. The majority of the Fed's agency MBS purchases were in the forward (TBA) market. Therefore, banks, knowing that the Federal Reserve is purchasing TBA MBS, respond by shifting resources away from new C&I lending into mortgage origination and MBS creation.

To test whether such crowding out took place, we focus on loan activity at the firm level so we are best able to address the concern that firm demand for capital, not changes in credit supply, is driving the results. The identification strategy is to compare the effect of asset purchases on the loan amounts or loan growth from multiple banks with the same firm. While this approach reduces the sample size to a set of firms that borrow frequently from multiple banks, it allows us to most extensively control for any firm demand factors. In Section 3.3, we look at the effect of asset purchases on banks' overall C&I lending activity.

3.2.1. Loan amount evidence

We estimate the impact of the asset purchases on the loan amount in quarter t for firm i that borrows from bank j as

$$\begin{aligned} Loan\ Amount_{ijt} = {} & \beta_1 Asset\ Purchases_{t-1} + \beta_2 Bank\ Exposure_{jt-1} \\ & + \beta_3 Bank\ Exposure_{jt-1} \times Asset\ Purchases_{t-1} \\ & + \beta_4 Bank\ Variables_{jt-1} + \beta_5 Loan\ Controls_{ijt} \\ & + \alpha_j + \theta_{it} + \epsilon_{ijt}. \end{aligned} \tag{2}$$

The coefficients of interest are β_3. We use firm by quarter fixed effects (θ_{it}) to remove any variation specific to a given firm in a given quarter. Any remaining differences in loan sizes, therefore, will not be driven by differences in firm demand for capital. We include bank fixed effects and the same set of bank-level controls as in Section 3.1 to control for other factors that could affect bank lending decisions. Although not our main focus, we also include the amount of Treasuries purchased by the Federal Reserve and a measure of bank exposure to these purchases. These additional variables allow us to disentangle the separate effects of MBS and Treasury purchases on bank lending.

Table 3
Firm-level loan amounts.

Columns 1 through 6 are panel fixed effect regressions. *Loan Amount* is the dollar amount of the facility divided by the lagged total assets of the firm and scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets and a value of zero if in the bottom tercile. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Loan controls" include indicators for whether the facility is for takeover purposes, is a revolving credit line, or is a term loan. "Orthogonalized MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Loan Amount					
Variable	(1)	(2)	(3)	(4)	(5)	(6)
High MBS Holdings × MBS Purchases	−0.176***		−0.374***	−0.553***		
	(0.0364)		(0.0942)	(0.0927)		
Securitizer × MBS Purchases					−0.224***	−0.368***
					(0.0621)	(0.0864)
High Securities Holdings		1.493*	−1.157	−2.958		−3.329***
		(0.841)	(1.178)	(5.582)		(1.050)
High Securities Holdings × TSY Purchases		−0.0193	0.314**	0.0285		0.258***
		(0.0537)	(0.127)	(0.0573)		(0.0896)
Bank's Size	4.094	3.425	2.755	−32.79**	2.289	1.006
	(2.554)	(2.527)	(2.025)	(13.29)	(2.031)	(1.610)
Bank's Equity Ratio	−0.517	−0.445	−0.932**	7.097***	−0.311	−0.500
	(0.425)	(0.472)	(0.458)	(0.589)	(0.400)	(0.379)
Bank's Net Income	−0.871	−0.628	−0.121	5.553**	−0.352	0.334
	(1.098)	(1.098)	(1.035)	(2.166)	(1.097)	(1.063)
Bank's Cost of Deposits	−8.323***	−7.645***	−9.347***	−69.04***	−8.903***	−10.02***
	(1.211)	(1.398)	(1.632)	(4.199)	(1.205)	(1.549)
Bank's Cash to Assets	−17.89**	−14.28	8.391	−182.6***	−0.379	27.75**
	(8.352)	(11.46)	(12.93)	(31.06)	(9.542)	(12.53)
Bank's Loans to Deposits	0.289***	0.278**	0.364***	1.370***	0.313***	0.375***
	(0.0992)	(0.112)	(0.114)	(0.118)	(0.102)	(0.108)
Change in Unemp. Rate, Bank's Counties	−0.378	0.204	−0.667	11.90***	−1.337	−2.197
	(0.843)	(0.767)	(0.886)	(1.006)	(1.202)	(1.390)
Loan controls	Yes	Yes	Yes	Yes	Yes	Yes
Orthogonalized MBS and securities holdings	No	No	No	Yes	No	No
Firm-by-quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	402	402	402	277	402	402
Adjusted R^2	0.446	0.443	0.440	0.835	0.446	0.441

Finally, the specifications contain the following loan-level controls: indicators for whether the facility is for takeover purposes, whether it is a revolving credit line, or whether it is a term loan.

Table 3 reports the results. Columns 1–4 use the exposure variable based on MBS holdings and Columns 5 and 6 use the exposure variable based on high-MBS securitizer banks. All columns that include Treasury purchases use the exposure measure based on non-MBS securities holdings.[12] Banks with higher securities holdings will benefit more from Treasury purchases lowering yields on these securities.

Column 1 provides the estimate of the impact of MBS purchases by the Federal Reserve on the credit supply of banks with higher MBS holdings. When the lending bank is in the top tercile of MBS holdings, a 1% increase in MBS purchases in the prior quarter leads to a 17.6 basis point reduction in the loan amount (as scaled by the firm's assets). Column 2 does not find statistically significant effects for Treasury purchases. Column 3, which covers both types of asset purchases, shows that the negative effect of MBS purchases on loan amounts from banks with higher MBS holdings is present as in Column 1. In contrast, loan amounts increase due to Treasury purchases. In Column 4, we calculate the MBS and securities holdings for each bank orthogonalized to the bank's characteristics. This alternative method of classifying banks with high MBS or securities holdings leads to a larger effect for MBS purchases. The effect of Treasury purchases is statistically insignificant in this case. Columns 5 and 6 investigate high-MBS securitizer banks and find that MBS purchases led to a negative effect in these cases as well. Column 6 finds that Treasury purchases have a positive effect in the case of banks with high securities holdings. These results support the observation that MBS and Treasury purchases have different effects.

Overall, we find that when controlling for firm demand factors by comparing loans given to the same firm in the same quarter, banks with higher exposure to MBS purchases (whether measured by high MBS holdings or active securitization) respond by reducing the amount of capital supplied to borrowing firms.

[12] Because none of the banks in this subsample switches between the high and low classifications for the MBS and securitizer exposure measures, the stand-alone coefficients (β_2) are absorbed by the bank fixed effects α_j.

3.2.2. Loan growth evidence

Section 3.2.1 compared loan amounts from different banks with the same firm in the same period to most extensively control for firm-specific demand effects. A complementary approach is to track changes in the individual syndicate loan shares of specific banks to a given firm before and after asset purchases. As in Section 3.2.1, while the sample of firms that borrow from multiple banks over a short period of time is small, this approach allows us to most robustly address firm demand concerns.

Following Khwaja and Mian (2008) and Lin and Paravisini (2012), among others, this section investigates the firm-bank pair loan growth after controlling for firm characteristics and aggregate economic conditions. Using loan-level data from DealScan, we first create a measure for the total supply of credit by each bank to each firm in Compustat, similar to a credit registry. This panel shows the credit supply of banks active in the commercial lending market to the firms in our sample. We then calculate firm-bank pair level loan growth. When a new loan is initiated, we compare that amount (including any additional loans in the subsequent three quarters) with the amount borrowed in the prior year.[13] Aggregating loan data over multiple periods is helpful as new loans are not initiated every period between each bank and firm. The regression specification that estimates the impact of the asset purchases on commercial lending in year t for firm i, which borrows from bank j, is

$$\begin{aligned} \textit{Loan Growth}_{ijt} =& \beta_1 \textit{Asset Purchases}_{t-1} + \beta_2 \textit{Bank Exposure}_{jt-1} \\ &+ \beta_3 \textit{Bank Exposure}_{jt-1} \times \textit{Asset Purchases}_{t-1} \\ &+ \beta_4 \textit{Bank Variables}_{jt-1} + \alpha_j + \theta_{it} + \epsilon_{ijt}. \end{aligned} \tag{3}$$

We include bank fixed effects (α_j) in all specifications. We also include firm-year fixed effects (θ_{it}) to control for any firm demand explanations. Identification in this case is obtained over the cross section of banks lending to the same firm in the same period of time.

Table 4 reports the results. Column 1 shows that syndicate banks in the top tercile of MBS holdings have lower loan growth for individual firms in response to additional MBS purchases, suggesting that a reduction in firm demand cannot explain our results. Column 2 considers the impact of Treasury purchases and finds a positive and statistically significant effect. Column 3 includes the interaction terms for the exposure of banks to both types of asset purchases. The point estimate of the interaction of MBS purchases with bank exposure (β_3) remains similar to that in Column 1. The effect of Treasury purchases on exposed banks remains positive and significant.

We refine the MBS and securities holdings measures by orthogonalizing these holdings to other bank characteristics and ranking them based on the refined measures (Column 4). We find a negative and statistically significant effect. Columns 5 and 6 focus on high-MBS securitizer banks. Column 5 shows that, similar to banks with high MBS holdings, higher MBS purchases by the Federal Reserve lead to less firm-level loan growth for securitizing banks. Column 6 includes Treasury purchases and reports effects that are similar in magnitude to those in Column 5.

3.3. Effects on bank-level commercial lending

Using the sample of borrowers with multiple loans and lenders in Section 3.2, we are able to establish that loan reductions are not driven by a drop in firm demand for capital. We next consider the effect of asset purchases on the bank's overall commercial lending activity. Here, we utilize quarterly C&I loan growth as our measure of interest. Specifications include the following bank-level characteristics: size, equity ratio, net income, cost of deposits, loans to deposits, and cash to assets. We address persistent heterogeneity among banks by including bank-level fixed effects. We include quarter fixed effects to control for changes in aggregate economic conditions, as well as changes in the unemployment rate across the bank's counties of operation to control for local economic conditions faced by the bank.

Table 5 reports the growth in C&I lending as a response to MBS and Treasury purchases. Columns 1–4 identify the effects on credit supply depending on whether the bank is in the top or bottom tercile of MBS holdings as a fraction of assets. Columns 5 and 6 focus on high-MBS securitizer banks to identify the effect of MBS purchases on credit supply. All columns use the exposure measure based on whether the bank is in the top or bottom tercile of non-MBS securities holdings to identify the effect of Treasury purchases on lending at the bank level.

The variables of interest are the bank-level interaction terms with the amounts of MBS and Treasury purchases. Column 1 shows that banks in the top tercile of MBS holdings, and hence benefit more from MBS purchases, have lower C&I loan growth in response to MBS purchases by the Federal Reserve. Because the dependent variable is quarterly and scaled by one hundred, Column 1 reports that a 1% increase in MBS purchases reduces loan growth by about 0.064 bps. Column 2 shows that banks with higher holdings of securities reacted positively to Treasury purchases in terms of C&I lending.[14] A 1% increase in Treasury purchases leads to 0.117 bps of additional C&I loan growth. Column 3 includes both MBS and Treasury purchases and finds that the effects from Columns 1 and 2 remain similar in magnitude and statistical significance. If a capital gains channel is the main cause for the positive effect of Treasury purchases on C&I lending, then the negative impact of the mortgage origination channel on commercial lending must dominate any analogous positive capital gains channel for MBS holdings.

As in Sections 3.1 and 3.2, a possible concern is that banks with high MBS holdings have other characteristics driving their C&I lending. Hence, we calculate the MBS holdings of a bank beyond what is predicted by observable bank characteristics. This orthogonalizes banks' MBS holdings to other bank characteristics. We perform an

[13] Here, we consider other syndicate banks in addition to the lead agent. The loan allotment is determined using the provided lender share data in DealScan. For those loans without share data, we estimate the share using the bank's role in the syndicate and the syndicate size.

[14] Table C.2 in Online Appendix Section C.1 finds similar results using a narrower definition of securities most likely affected by Treasury purchases.

Table 4
Firm-level loan growth.

Columns 1 through 6 are panel fixed effect regressions. *Firm Loan Growth* is the loan growth for a specific bank lending to a specific firm, expressed as a quarterly percentage. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. "Orthogonalized MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Firm Loan Growth					
Variable	(1)	(2)	(3)	(4)	(5)	(6)
High MBS Holdings				-0.142		
				(7.131)		
High MBS Holdings × *MBS Purchases*	−1.423***		−1.559***	−1.709***		
	(0.454)		(0.455)	(0.466)		
Securitizer					2.210	0.756
					(3.685)	(3.279)
Securitizer × *MBS Purchases*					−1.993***	−1.852**
					(0.748)	(0.799)
High Securities Holdings		17.72***	18.79***			17.52***
		(5.782)	(5.284)			(6.025)
High Securities Holdings × *TSY Purchases*		0.511**	0.763***	1.032***		0.373**
		(0.200)	(0.237)	(0.293)		(0.189)
Bank's Size	−9.919	−6.094	−5.346	−49.48	−10.42	−6.233
	(12.24)	(13.46)	(13.36)	(39.53)	(12.98)	(14.07)
Bank's Equity Ratio	−1.839***	−1.878***	−1.924***	−1.933	−2.090***	−2.084***
	(0.674)	(0.626)	(0.658)	(2.167)	(0.701)	(0.682)
Bank's Net Income	2.094	0.270	0.624	3.468	1.718	0.416
	(1.829)	(1.806)	(1.860)	(4.961)	(1.830)	(1.890)
Bank's Cost of Deposits	0.783	1.227	1.812	−0.145	0.371	1.180
	(2.743)	(3.058)	(2.554)	(4.042)	(3.178)	(3.101)
Bank's Cash to Assets	−14.14	−8.966	−23.87	−79.45	−7.487	−12.22
	(25.97)	(23.54)	(26.53)	(93.52)	(25.55)	(24.88)
Bank's Loans to Deposits	0.202***	0.134*	0.147**	0.324*	0.198**	0.148*
	(0.0754)	(0.0728)	(0.0711)	(0.195)	(0.0815)	(0.0760)
Change in Unemp. Rate, Bank's Counties	−11.04***	−11.97***	−11.23***	−10.23***	−11.33***	−11.54***
	(2.314)	(2.469)	(2.284)	(3.501)	(2.741)	(2.743)
Orthogonalized MBS and securities holdings	No	No	No	Yes	No	No
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	950	950	950	497	950	950
Adjusted R^2	0.753	0.749	0.754	0.746	0.750	0.750

analogous procedure for the securities holdings as well. Column 4 reports that the results remain statistically and economically significant. Banks with higher MBS holdings provide fewer new C&I loans compared with banks with lower MBS holdings. In Section 5.2, we perform two additional robustness tests. (1) We interact MBS purchases with additional bank characteristics and, (2) we repeat our analysis using a matched sample of banks. In both cases, we find similar results.

Columns 5 and 6 focus on high-MBS securitizer banks to confirm that the observed effects are stronger for banks that benefit more from MBS purchases. We find effects approximately six times stronger in Column 5 compared with Column 1. A 1% increase in MBS purchases leads to about 0.364 bps lower C&I loan growth for securitizing banks. As detailed in Online Appendix B, we calculate that for each dollar of additional MBS purchases by the Federal Reserve, high-MBS securitizer banks reduced C&I lending by 1.22 cents. Comparing this estimate from Column 5 with estimates obtained from Column 3 in Table 2 (the corresponding specification), we find that for each dollar of additional mortgage lending due to QE MBS purchases, C&I lending by securitizer banks went down by 34 cents. Column 6 shows that controlling for bank exposure to Treasury purchases does not change the results obtained in Column 5.

3.4. Recent work and our results

While it is not the main focus of their paper, Rodnyansky and Darmouni (2017) find some evidence that C&I lending remained flat or grew during quantitative easing. Their evidence contrasts with our findings in Sections 3.2.2 and 3.3, which are the closest specifications to those in their paper (Tables 6 and 7 of Rodnyansky and Darmouni, 2017). The difference in our results is due to key differences in the research design.

The first main difference in our specifications is that our paper utilizes quarter by quarter asset purchases along with time fixed effects in all our specifications (*Difference #1*). In comparison, Rodnyansky and Darmouni (2017) utilize the timing of QE rounds as the source of exogenous variation to create three time dummies for the QEs. Our approach allows us to separate the effects of asset

Table 5
Bank-level commercial and industrial (C&I) loan growth.

Columns 1 through 6 are panel fixed effect regressions. *C&I Loan Growth* is the growth rate in C&I loans between the current and prior quarter, scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Orthogonalized MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	C&I Loan Growth					
Variable	(1)	(2)	(3)	(4)	(5)	(6)
High MBS Holdings	−0.502		−0.412	0.0250		
	(0.467)		(0.466)	(0.779)		
High MBS Holdings × MBS Purchases	−0.0642***		−0.0609***	−0.0936***		
	(0.0201)		(0.0201)	(0.0321)		
Securitizer					2.505*	2.434*
					(1.367)	(1.361)
Securitizer × MBS Purchases					−0.364***	−0.360***
					(0.0940)	(0.0934)
High Securities Holdings		0.237	0.112	1.701***		0.223
		(0.583)	(0.585)	(0.605)		(0.583)
High Securities Holdings × TSY Purchases		0.117***	0.115***	0.0469		0.117***
		(0.0299)	(0.0300)	(0.0359)		(0.0299)
Bank's Size	−1.789***	−1.870***	−1.938***	−2.169***	−1.674***	−1.851***
	(0.367)	(0.377)	(0.379)	(0.496)	(0.363)	(0.377)
Bank's Equity Ratio	0.912***	0.908***	0.906***	0.870***	0.918***	0.911***
	(0.0627)	(0.0627)	(0.0624)	(0.0862)	(0.0630)	(0.0627)
Bank's Net Income	0.573***	0.575***	0.581***	0.348*	0.562***	0.572***
	(0.140)	(0.140)	(0.140)	(0.192)	(0.141)	(0.140)
Bank's Cost of Deposits	−0.651**	−0.709**	−0.711**	−0.473	−0.663**	−0.724**
	(0.312)	(0.312)	(0.312)	(0.404)	(0.312)	(0.311)
Bank's Cash to Assets	0.0341*	0.0528***	0.0448**	0.0683**	0.0406**	0.0518**
	(0.0197)	(0.0202)	(0.0204)	(0.0286)	(0.0195)	(0.0202)
Bank's Loans to Deposits	−0.143***	−0.135***	−0.140***	−0.175***	−0.139***	−0.135***
	(0.0129)	(0.0127)	(0.0130)	(0.0164)	(0.0126)	(0.0127)
Change in Unemp. Rate, Bank's Counties	−0.331***	−0.334***	−0.334***	−0.418***	−0.332***	−0.335***
	(0.0669)	(0.0669)	(0.0669)	(0.0899)	(0.0669)	(0.0669)
Orthogonalized MBS and securities holdings	No	No	No	Yes	No	No
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	77,935	77,935	77,935	45,618	77,935	77,935
Adjusted R^2	0.0567	0.0568	0.0570	0.0709	0.0566	0.0569

purchases from other contemporary economic events.[15] Our identification is obtained from within-quarter cross-sectional differences in the response to asset purchases only. Further, we distinguish between MBS purchases and Treasury purchases. As QE1 and QE3 had both MBS and Treasury purchases, it is important to distinguish the impact of each security as they have different effects on lending. This point is lost in a specification that uses only QE indicators, as both types of purchases are commingled. By using only MBS-related treatments for QE1 and QE3, Rodnyansky and Darmouni (2017) assume that MBS purchases are the only channel of note.[16] We find that while MBS purchases had a negative effect on C&I lending, Treasury purchases had a positive effect on C&I lending. Thus, one reason that Rodnyansky and Darmouni (2017) find a flat or positive effect on C&I lending during QE1 and QE3 could be due to Treasury purchases during those periods.

Other key differences in our specifications exist as well.[17] Online Appendix Section C.2 compares our results with those of Rodnyansky and Darmouni (2017). It also confirms that our results are robust to using their set of controls. Beyond the results in Sections 3.2 and 3.3, the crowding-out effect of monetary stimulus on C&I lending

[15] In addition, we capture the other sizable asset purchases that the Federal Reserve conducted between rounds (Fig. 1).

[16] The reason the authors suggest that they can ignore Treasury purchases is that banks do not hold as much Treasury securities as MBS. However, they ignore non-Treasury US government agency securities. Our summary statistics (Table 1, Panel A) show that banks hold approximately 8.2% of assets in US government securities, which is similar to the average MBS holdings of 7.1% of assets. Further, the total non-MBS securities holdings are approximately 14% of assets, which should also benefit from Treasury purchases through lower interest rates.

[17] Another important difference is the choice of outcome variable (*Difference #2*). Rodnyansky and Darmouni (2017) use the total balance sheet amount of loans, whereas we focus on the growth in loans in response to the treatment of asset purchases from the prior quarter. As the Federal Reserve's MBS purchases primarily affect banks' new mortgage origination activity, the principal effect of these new originations is on the crowding out of new C&I lending. We believe this crowding-out effect is better measured by C&I loan growth. In this choice, our approach is similar to Kashyap and Stein (2000) and Khwaja and Mian (2008). Further, we control throughout for heterogeneity across banks using bank-level controls and bank fixed effects (*Difference #3*).

guides our subsequent analysis in general. The rest of the paper seeks to further establish, using multiple empirical strategies, that MBS purchases led to the crowding out of C&I lending and adversely affected firms.

4. Crowding-out effects on firms

An important question that we address in this paper is whether QE has unintended real effects on firm outcomes. Our approach evaluates the impact of monetary policy on the real economy. To do so, we trace the impact of asset purchases by the Federal Reserve through banks' balance sheets onto firms that have financing relationships with those banks. Thus, the aggregate impact of asset purchases is identified using micro-data at the firm level. Section 4.1 looks at the impact of asset purchases on firm investment. Section 4.2 considers how the reduction in lending affected firms' other financing decisions.

4.1. Unintended real effects on firm investment

Focusing on the bank lending channel, we consider the investment of firm i in quarter t that borrows from bank j:

$$\begin{aligned} Investment_{ijt} = {} & \beta_1 Asset\ Purchases_{t-1} + \beta_2 Bank\ Exposure_{jt-1} \\ & + \beta_3 Bank\ Exposure_{jt-1} \times Asset\ Purchases_{t-1} \\ & + \beta_4 Firm\ Variables_{it-1} \\ & + \beta_5 Bank\ Variables_{jt-1} + \alpha_{ij} + \gamma_{s_i t} + \epsilon_{ijt}. \end{aligned} \tag{4}$$

The coefficients of interest are the interaction variables that capture the heterogeneous impact of MBS and Treasury purchases depending on the exposure of the lending bank to these purchases. We continue to use the exposure measures determined by dividing banks into terciles based on MBS and non-MBS securities holdings. We also consider the group of high-MBS banks that report securitization income. These banks, based on our mechanism, should be the most affected by QE.[18]

All specifications include the following firm-level characteristics: contemporaneous firm cash flow, Tobin's q, the financial health of the firm as measured by the Altman Z-Score, and firm size. The same bank-level controls as in Section 3 are included as well. The investment regressions include firms that have an active lending relationship with at least one bank in a given quarter. The unit of observation in this panel is, therefore, a firm-bank-quarter observation.

When focusing on firm-level real effects of bank-level shocks, an additional identification challenge arises. Firms with different capital demands can match with banks that have different exposures to these asset purchases. We address this possibility in multiple ways. First, in all specifications, we include firm-bank pair fixed effects, which remove any time-invariant differences across lending relationships (α_{ij}). Second, in addition to standard firm-level controls, all specifications include firm's state by quarter fixed effects ($\gamma_{s_i t}$).[19] These fixed effects remove any common economic shocks to all firms headquartered in a given state, regardless of their lending bank's location. Third, to address time-variant matching between banks and firms, we include interaction terms between firm characteristics and the bank exposure measures.[20]

Table 6 reports the results. In Column 1, the coefficient of the interaction term High MBS Holdings × MBS Purchases shows that firms that borrowed from banks with higher MBS holdings decreased investment following higher MBS purchases from the Federal Reserve. A 1% increase in MBS purchases leads to a reduction of 0.037 bps of investment as a fraction of property, plant, and equipment for firms that borrow from the high-MBS banks. The coefficient of the interaction term High Securities Holdings × TSY Purchases in Column 2 is statistically insignificant. This suggests that the impact of asset purchases on firm investment through the bank lending channel is asymmetric for Treasury and MBS purchases. While MBS purchases have a negative effect, Treasury purchases do not. Column 3 combines the two types of asset purchases and finds similar results. Column 4 calculates the residual MBS holdings and residual non-MBS securities holdings after controlling for other bank characteristics. The coefficient of the interaction term for banks in the highest orthogonalized MBS holdings tercile and MBS purchases is statistically and economically similar to the coefficients in Columns 1 and 3. In investment regressions, measurement error of investment opportunities is an important concern (Erickson and Whited, 2000; 2012). We utilize the cumulant estimator from Erickson et al. (2014) in our Column 5 to address the errors-in-variables issue for Tobin's q as a proxy for investment opportunities.[21] The impact of MBS purchases as part of QE on firm investment remains similar under this approach.

Columns 6 and 7 test our mechanism further by focusing on banks that are securitizers and are in the highest tercile of MBS holdings. In both columns, we find that firms borrowing from high-MBS securitizer banks invest less in response to MBS asset purchases. Using the estimates from Column 6, in Online Appendix B, we calculate that for an additional dollar of MBS purchases by the Federal Reserve, firms borrowing from high-MBS securitizer banks reduce their investment by 0.425 cents. Scaling the reduction in investment by the additional mortgage lending stimulated through MBS purchases by the Federal Reserve (3.63 cents as discussed in Section 3.1), we find that firms reduce their investment by 12 cents for each dollar increase in mortgage lending by securitizing banks.

These results show the unintended real effects of MBS purchases during QE, that is, a negative effect of MBS purchases on firm investment through the bank lending channel. We do not find statistically significant evidence

[18] We present similar specifications that instead use continuous versions of the MBS and securities holdings variables over the full sample in Online Appendix Section C.3.

[19] The firm's state by quarter fixed effects absorb the coefficients for *MBS Purchases* and *Treasury Purchases*.

[20] As an additional test, Section 5.3 repeats the analysis of this section on a matched sample of firms.

[21] We use a fifth-order cumulant estimator to treat the measurement error in the Tobin's q variables.

Table 6
Impact of monetary stimulus on firms.

Columns 1 through 7 are panel fixed effect regressions. *Investment* is the firm's quarterly capital expenditures divided by lagged gross property, plant, and equipment, scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. "Additional firm interactions" include the firm variables (*Cash Flow, Lagged Tobin's q, Lagged Z-Score, Lagged Firm Size*) interacted with *High MBS Holdings, High Securities Holdings*, or *Securitizer* variables, depending on the specification. "Orthogonalized MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. "Cumulant estimation" treats the *Lagged Tobin's q* variables as potentially mismeasured regressors. Standard errors are clustered by firm and bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Investment						
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
High MBS Holdings	−1.422		−1.572	−0.240	−1.067		
	(1.220)		(1.538)	(0.251)	(1.246)		
High MBS Holdings × MBS Purchases	−0.0371***		−0.0436***	−0.0312***	−0.0370***		
	(0.00837)		(0.0106)	(0.0108)	(0.0119)		
Securitizer						−1.249	−1.377
						(1.111)	(1.350)
Securitizer × MBS Purchases						−0.0355***	−0.0372**
						(0.0137)	(0.0147)
High Securities Holdings		0.178	0.192	−0.272*	−0.0215		0.0113
		(0.348)	(0.364)	(0.148)	(0.388)		(0.354)
High Securities Holdings × TSY Purchases		−0.000856	−0.00502	−0.0160	−0.000362		−0.00832
		(0.0121)	(0.00997)	(0.0123)	(0.0171)		(0.0111)
Cash Flow	1.850***	0.583	1.480***	0.571	1.545**	1.342***	0.826
	(0.0678)	(0.392)	(0.406)	(0.389)	(0.750)	(0.494)	(0.791)
Lagged Tobin's q	0.214***	0.133***	0.185***	0.204***	0.209***	0.223***	0.203***
	(0.0114)	(0.0374)	(0.0312)	(0.0185)	(0.0263)	(0.0187)	(0.0206)
Lagged Z-Score	0.253***	0.151**	0.230***	0.201***	0.204*	0.189***	0.162***
	(0.0842)	(0.0680)	(0.0733)	(0.0400)	(0.124)	(0.0560)	(0.0412)
Lagged Firm Size	0.279	−0.159	0.237	0.120	0.248	0.189	0.150
	(0.293)	(0.285)	(0.349)	(0.155)	(0.276)	(0.306)	(0.365)
Bank's Size	0.146	0.114	0.163	0.827***	0.0820	0.150	0.151
	(0.250)	(0.271)	(0.243)	(0.286)	(0.361)	(0.254)	(0.251)
Bank's Equity Ratio	0.00715	0.0265	0.00872	−0.0163	0.00880	0.0186	0.0210
	(0.0329)	(0.0305)	(0.0336)	(0.0345)	(0.0475)	(0.0316)	(0.0333)
Bank's Net Income	−0.136*	−0.120	−0.122*	−0.0376	−0.177**	−0.133*	−0.130*
	(0.0697)	(0.0955)	(0.0741)	(0.0872)	(0.0867)	(0.0729)	(0.0760)
Bank's Cost of Deposits	0.0411	0.0978	0.0972	0.0177	0.0104	0.00412	0.0336
	(0.171)	(0.160)	(0.163)	(0.169)	(0.206)	(0.174)	(0.174)
Bank's Cash to Assets	1.070	2.419**	1.469	−3.686**	−0.405	1.834*	1.641
	(1.053)	(1.005)	(1.000)	(1.848)	(1.993)	(1.087)	(1.105)
Bank's Loans to Deposits	−0.0130***	−0.0154***	−0.0130***	−0.00963	−0.0166***	−0.0136***	−0.0139***
	(0.00447)	(0.00406)	(0.00436)	(0.00670)	(0.00644)	(0.00472)	(0.00507)
Change in Unemp. Rate, Bank's Counties	−0.0249	0.0137	−0.0170	0.104	−0.0925	0.00650	−0.000151
	(0.0876)	(0.0989)	(0.0940)	(0.0930)	(0.0897)	(0.0977)	(0.0984)
Additional firm interactions	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Orthogonalized MBS and securities holdings	No	No	No	Yes	No	No	No
Firm-bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm state by quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cumulant estimation	No	No	No	No	Yes	No	No
Number of observations	29,980	29,980	29,980	27,439	29,980	29,980	29,980
Adjusted R^2	0.507	0.507	0.508	0.533	0.503	0.508	0.508

that Treasury purchases affect firm investment through its lending bank, suggesting that Treasury purchases and MBS purchases are dissimilar instruments for transmitting economic stimulus.[22]

4.2. Firm financing decisions

This section investigates how firm financing decisions are affected by asset purchases. We look at how firms with lending relationships change their amounts of debt and equity following the Federal Reserve's asset purchases. The specifications are very similar to the firm investment spec-

[22] An alternative approach to conduct the analysis in this section is to aggregate the characteristics of all banks lending to a firm in a given quarter into those of one average bank. Our results are generally robust in this case as well. We prefer our framework because we can explicitly control for differences in specific lending relationships with firm-bank fixed effects. For example, the nature of a bank's relationship with an established multinational firm can be very different from its relationship with a young smaller firm (see Petersen and Rajan, 1994; Karolyi, 2017, for example, regarding the importance of lending relationships). Our identification is then obtained within a firm-bank relationship. Specifically, how the treatment of monetary stimulus affects a firm through a specific bank over the course of their relationship.

Table 7
Impact of monetary stimulus on firm financing.

Columns 1 through 4 are panel fixed effect regressions. *Change in Debt* is the firm's quarterly change in total debt outstanding, divided by the prior quarter's assets and scaled by one hundred. *Change in Equity* is the percentage change in shares of outstanding common equity. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. "Additional firm interactions" include the firm variables (*Lagged Market-to-Book, Lagged Firm Size, Lagged Profitability, Lagged Tangibility*) interacted with *High MBS Holdings, High Securities Holdings*, or *Securitizer* variables, depending on the specification. Standard errors are clustered by firm and bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Change in Debt		*Change in Equity*	
Variable	(1)	(2)	(3)	(4)
High MBS Holdings	14.18***		11.93***	
	(1.433)		(3.208)	
High MBS Holdings × MBS Purchases	−0.0321**		0.00647	
	(0.0126)		(0.0235)	
Securitizer		11.27***		9.209***
		(2.581)		(2.530)
Securitizer × MBS Purchases		−0.0389**		0.00826
		(0.0197)		(0.0237)
High Securities Holdings	2.193**	2.195**	0.142	0.483
	(0.876)	(0.979)	(0.865)	(0.779)
High Securities Holdings × TSY Purchases	0.0320	0.0216	0.0499*	0.0524*
	(0.0209)	(0.0232)	(0.0273)	(0.0291)
Lagged Market-to-Book	1.059***	0.981***	−0.571**	−0.281
	(0.117)	(0.132)	(0.279)	(0.183)
Lagged Firm Size	−5.786***	−4.940***	−5.021***	−4.625***
	(0.425)	(0.766)	(0.859)	(0.563)
Lagged Profitability	−0.178**	−0.162***	0.0600	0.0738
	(0.0729)	(0.0628)	(0.0617)	(0.0453)
Lagged Tangibility	0.0764***	0.0777***	−0.0365	0.00156
	(0.0178)	(0.0175)	(0.0258)	(0.0173)
Bank's Size	−0.267	−0.221	0.579	0.605
	(0.664)	(0.670)	(0.411)	(0.415)
Bank's Equity Ratio	0.0167	−0.0134	0.0670	0.0360
	(0.0602)	(0.0634)	(0.0930)	(0.0890)
Bank's Net Income	−0.0823	−0.103	0.137	0.128
	(0.124)	(0.127)	(0.151)	(0.156)
Bank's Cost of Deposits	−0.0637	−0.0339	0.295	0.375*
	(0.297)	(0.302)	(0.213)	(0.219)
Bank's Cash to Assets	−0.974	−1.164	−1.270	−1.660
	(2.216)	(2.619)	(2.244)	(2.481)
Bank's Loans to Deposits	−0.0147*	−0.00692	−0.0191*	−0.0166
	(0.00876)	(0.0101)	(0.0109)	(0.0104)
Change in Unemp. Rate, Bank's Counties	0.0882	0.0759	−0.0707	−0.0601
	(0.241)	(0.244)	(0.144)	(0.151)
Additional firm interactions	Yes	Yes	Yes	Yes
Firm-bank fixed effects	Yes	Yes	Yes	Yes
Firm state by quarter fixed effects	Yes	Yes	Yes	Yes
Number of observations	29,980	29,980	29,980	29,980
Adjusted R^2	0.111	0.110	0.171	0.171

ifications in Section 4.1. As we are considering firm financing, not firm investment, we utilize a different set of firm controls. We control for the firm's size, market-to-book ratio, profitability, and tangibility. As in the specifications in Table 6, we include firm's state by quarter fixed effects, firm-bank fixed effects, and the same set of bank-level controls. We also interact firm controls with the lending bank's MBS holdings, securities holdings, and securitizer status to help control for possible time-varying matching concerns between firms and banks.

Table 7 reports the results. Columns 1 and 2 focus on the change in debt. The negative coefficient of the interaction term *High MBS Holdings × MBS Purchases* in Column 1 suggests that firms borrowing from banks with higher MBS holdings take on less debt following MBS purchases than firms borrowing from banks with lower MBS holdings. These firms do not completely substitute alternative sources of debt financing when banks reduce lending. Column 2, which uses a bank's status as a securitizer to classify exposure to MBS purchases, finds similar results. Columns 3 and 4 investigate whether these firms obtain more equity financing. No evidence exists that these firms substituted debt financing with equity financing.

In combination with the findings in Section 4.1 that show the unintended negative effects of MBS purchases on firm investment, these results help complete the picture.

That is, firms do not obtain alternative sources of financing to completely compensate for the reduction in C&I lending due to the Federal Reserve's MBS purchases.

5. Other endogeneity concerns

Our analyses in Sections 3 and 4 take many steps to rule out possible contaminating effects, such as changes in firm demand for capital or other concurrent economic or policy events. Throughout our analyses, our identification strategy assumes that different measures of bank exposure capture the different incentives of banks. Given the importance of the mortgage origination channel for our argument, these measures should be capturing fundamentally different mortgage business models for banks. In other words, the tercile rank of MBS holdings, as well as whether a bank is a securitizer, should not fluctuate with period-by-period asset purchases. Section 5.1 discusses the source of variation in MBS holdings and its persistence.

Section 5.2 provides additional tests to address concerns that other bank characteristics, and not MBS holdings or securitizer status, are the reason behind the differential response of banks to asset purchases. Section 5.3 addresses concerns that differences in characteristics of firms, not the differences in banks, are driving the differential outcomes of firms.

5.1. Source of variation in MBS holdings

Given that our identification strategy uses cross-sectional differences in bank mortgage activity, it is important to better understand the source of variation in the MBS holdings of banks. We find that the relative grouping of banks in terms of MBS holdings and securitization status is persistent. On average, about 96% of banks remain as a high-MBS bank or a low-MBS bank from quarter to quarter.[23] Furthermore, banks with high MBS holdings have approximately 15% of assets in MBS, and the banks with low MBS holdings hold a very small percentage of their portfolio in MBS.

What explains a bank's decision to hold MBS? We find that banks with high MBS holdings are larger and have a lower cost of deposits. At the same time, banks with more MBS holdings seem to be exploiting opportunities in the mortgage market more aggressively than the low-MBS holdings banks. These banks are growing their mortgage portfolios 3 percentage points (pp) faster (in terms of national mortgage origination growth rate) from a larger base (more than three times higher average mortgage origination market share). In terms of business strategy, they are growing their mortgage portfolio by aggressively competing on interest rates (offering an average of 33 bps or 89 bps lower rates for 30-year and 15-year fixed rate mortgages, respectively).

These banks with faster mortgage growth appear to have more financial constraints. Banks with high MBS holdings have a 0.6 pp lower average equity ratio and 30% lower cash holdings relative to the average for low-MBS banks.[24] The business model of these banks favors investment in mortgages at the expense of US government securities: High-MBS banks hold 50% less US government securities compared with banks with low MBS holdings. On average, banks with high MBS holdings are more involved in mortgage markets. In terms of C&I lending, both groups of banks have similar lending growth on average.[25]

5.2. Heterogeneity across banks

Section 5.1 suggests that banks' MBS holdings and securitization status are persistent and likely are not driven by the Federal Reserve's asset purchases. Still, one could be concerned that other channels, and not mortgage activity captured by MBS holdings or securitizer status, are driving the response of banks to asset purchases. To address this concern, we take the following steps. First, throughout the paper, we report a specification in which we utilize a bank's MBS holdings orthogonalized to other bank characteristics (size, equity ratio, net income, cost of deposits, cash to assets, and loans to deposits). In this case, only MBS holdings that are not explained by other bank characteristics are used to identify cross-sectional differences in bank responses.

Second, in an alternative manner, Table 8 interacts the other bank controls with the Federal Reserve's MBS purchases. Columns 1 and 2 of Table 8 report the effect of MBS purchases on C&I lending (similar to Table 5), and Columns 3 and 4 report the effect of MBS purchases on borrowing firms' investment (similar to Table 6). Comparing the coefficient of *High MBS Holdings* $\times$ *MBS Purchases* in Column 1 of Table 8 with Column 4 of Table 5, the point estimate is somewhat reduced. The point estimate in the case of securitizers is also lower compared with its equivalent specification (Column 2 versus Column 6 of Table 5). Nevertheless, the estimated effects remain statistically and economically significant.

These differences in point estimates suggest that other bank characteristics can explain a small portion of the effects. Larger banks appear to reduce commercial lending more in response to MBS purchases. As banks that are most exposed to the origination channel are of a certain scale to originate sufficient volume of new mortgages to securitize and sell to the Federal Reserve, it is intuitive that bank size captures a piece of the effect. The unintended negative consequences of MBS purchases on C&I lending, as captured through the MBS holdings or securitizer classifications, remain statistically and economically significant. In the case of firm investment reported in Columns 3 and 4, the point estimates remain similar to those in Columns 3 and 7 of Table 6, respectively.

[23] Online Appendix Table C.5 reports the transition probabilities. Table C.6 reports bank characteristics conditional on being included in the high or low MBS holdings terciles as well as the securitizer or non-securitizer groups.

[24] Demyanyk and Loutskina (2016) show that temporary mortgage holdings increase capital requirements for banks. Section 6.1 discusses bank constraints in some detail.

[25] Online Appendix Table C.6 shows no statistical difference in C&I loan growth between banks with high and low MBS holdings or between securitizers and non-securitizers.

Table 8
Asset purchases and other bank channels.

Columns 1 through 4 are panel fixed effect regressions. *C&I Loan Growth* is the growth rate in commercial and industrial (C&I) loans between the current and prior quarter, scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	C&I Loan Growth		*Investment*	
Variable	(1)	(2)	(3)	(4)
High MBS Holdings	−0.427		−1.227	
	(0.461)		(1.461)	
High MBS Holdings × MBS Purchases	−0.0520**		−0.0388**	
	(0.0224)		(0.0182)	
Securitizer		1.213		−1.218
		(1.385)		(1.250)
Securitizer × MBS Purchases		−0.211**		−0.0410***
		(0.0950)		(0.0129)
High Securities Holdings	1.040*	1.112*	0.153	0.0654
	(0.626)	(0.626)	(0.407)	(0.396)
High Securities Holdings × TSY Purchases	0.00777	0.0117	−0.0188	−0.0150
	(0.0414)	(0.0414)	(0.0139)	(0.0125)
Bank's Size	−1.670***	−1.596***	0.439*	0.387
	(0.388)	(0.387)	(0.233)	(0.237)
Bank's Equity Ratio	0.912***	0.911***	−0.0176	−0.0159
	(0.0753)	(0.0753)	(0.0405)	(0.0358)
Bank's Net Income	−0.702**	−0.735***	−0.00522	0.00502
	(0.281)	(0.282)	(0.167)	(0.167)
Bank's Cost of Deposits	−1.260***	−1.272***	0.0604	0.0171
	(0.406)	(0.406)	(0.223)	(0.235)
Bank's Cash to Assets	0.0361	0.0321	−2.072	−1.639
	(0.0400)	(0.0399)	(2.474)	(2.728)
Bank's Loans to Deposits	−10.25***	−10.11***	−0.0137***	−0.0144***
	(1.562)	(1.541)	(0.00489)	(0.00461)
Bank's Size × MBS Purchases	−0.0319***	−0.0334***	−0.00190	0.00571
	(0.00712)	(0.00711)	(0.00615)	(0.00428)
Bank's Equity Ratio × MBS Purchases	−0.00596	−0.00503	0.000177	−0.00454
	(0.00423)	(0.00418)	(0.00639)	(0.00530)
Bank's Net Income × MBS Purchases	0.0907***	0.0944***	0.00686	0.00753
	(0.0203)	(0.0204)	(0.0141)	(0.0141)
Bank's Cost of Deposits × MBS Purchases	0.00669	0.00773	0.0384	0.0407
	(0.0353)	(0.0352)	(0.0323)	(0.0294)
Bank's Cash to Assets × MBS Purchases	−0.000664	0.000571	0.247	0.281
	(0.00230)	(0.00221)	(0.230)	(0.215)
Bank's Loans to Deposits × MBS Purchases	−0.255***	−0.223***	0.000481	0.000897**
	(0.0598)	(0.0581)	(0.000345)	(0.000363)
Bank's Size × TSY Purchases	0.00705	0.00725	−0.000601	−0.000893
	(0.00848)	(0.00855)	(0.00311)	(0.00345)
Bank's Equity Ratio × TSY Purchases	−0.00185	−0.00191	0.00644*	0.00778**
	(0.00508)	(0.00509)	(0.00384)	(0.00364)
Bank's Net Income × TSY Purchases	0.0764***	0.0763***	−0.0129	−0.0143
	(0.0218)	(0.0219)	(0.0189)	(0.0188)
Bank's Cost of Deposits × TSY Purchases	0.0700*	0.0701*	−0.00700	−0.00720
	(0.0370)	(0.0370)	(0.0170)	(0.0173)
Bank's Cash to Assets × TSY Purchases	0.000535	0.000577	0.246*	0.212
	(0.00252)	(0.00252)	(0.147)	(0.154)
Bank's Loans to Deposits × TSY Purchases	−0.286***	−0.282***	−0.000151	−0.000137
	(0.0890)	(0.0891)	(0.000220)	(0.000234)
Change in Unemp. Rate, Bank's Counties	−0.348***	−0.349***	−0.0196	−0.00457
	(0.0669)	(0.0669)	(0.0980)	(0.101)
Bank fixed effects	Yes	Yes	No	No
Quarter fixed effects	Yes	Yes	No	No
Firm controls	No	No	Yes	Yes
Additional firm interactions	No	No	Yes	Yes
Firm-bank fixed effects	No	No	Yes	Yes
Firm state by quarter fixed effects	No	No	Yes	Yes
Number of observations	77,935	77,935	32,209	32,209
Adjusted R^2	0.0585	0.0584	0.509	0.509

Table 9
Bank-level commercial and industrial (C&I) loan growth, matched sample.

Columns 1 through 6 are panel fixed effect regressions. *C&I Loan Growth* is the growth rate in C&I loans between the current and prior quarter, scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve TSY purchases. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Orthogonalized MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	C&I Loan Growth, matched sample					
Variable	(1)	(2)	(3)	(4)	(5)	(6)
High MBS Holdings	−0.294		−0.247	−0.412		
	(0.592)		(0.596)	(1.005)		
High MBS Holdings × *MBS Purchases*	−0.0990***		−0.0967***	−0.0971**		
	(0.0306)		(0.0306)	(0.0419)		
Securitizer					2.787**	2.739**
					(1.398)	(1.394)
Securitizer × *MBS Purchases*					−0.401***	−0.398***
					(0.101)	(0.101)
High Securities Holdings		0.340	0.211	1.644*		0.324
		(0.834)	(0.840)	(0.860)		(0.833)
High Securities Holdings × *TSY Purchases*		0.0429	0.0367	−0.0113		0.0427
		(0.0443)	(0.0443)	(0.0575)		(0.0443)
Bank's Size	−1.213**	−1.179**	−1.298**	−1.277*	−1.037*	−1.158**
	(0.543)	(0.571)	(0.577)	(0.762)	(0.532)	(0.571)
Bank's Equity Ratio	0.762***	0.759***	0.760***	0.774***	0.765***	0.762***
	(0.0963)	(0.0970)	(0.0969)	(0.126)	(0.0965)	(0.0971)
Bank's Net Income	0.701***	0.695***	0.705***	0.306	0.685***	0.691***
	(0.206)	(0.206)	(0.206)	(0.273)	(0.206)	(0.206)
Bank's Cost of Deposits	−0.311	−0.320	−0.335	−0.0268	−0.308	−0.336
	(0.472)	(0.474)	(0.472)	(0.582)	(0.473)	(0.474)
Bank's Cash to Assets	0.0135	0.0218	0.0176	0.0234	0.0158	0.0211
	(0.0343)	(0.0355)	(0.0357)	(0.0435)	(0.0341)	(0.0355)
Bank's Loans to Deposits	−0.148***	−0.142***	−0.146***	−0.177***	−0.144***	−0.142***
	(0.0202)	(0.0202)	(0.0206)	(0.0251)	(0.0199)	(0.0202)
Change in Unemp. Rate, Bank's Counties	−0.394***	−0.394***	−0.395***	−0.501***	−0.394***	−0.395***
	(0.120)	(0.120)	(0.120)	(0.151)	(0.120)	(0.120)
Orthogonalized MBS and securities holdings	No	No	No	Yes	No	No
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	93,209	93,209	93,209	66,524	93,209	93,209
Adjusted R^2	0.107	0.107	0.107	0.129	0.107	0.107

We also reproduce our main commercial lending results (Table 5) using a matched sample. This third approach allows us to condition away observed differences across banks to confirm that these differences are not driving our results. In Table 9, we present the analogue of Table 5 using this matched sample. We estimate a bank's likelihood of being a high-MBS bank conditional on the set of bank control variables. We take the propensity score from this estimation and perform a nearest neighbor match for each high-MBS bank observation to its closest low-MBS bank observation. To ensure the best possible matches, we choose to match with replacement (Roberts and Whited, 2013). Across the specifications of Table 9, we find estimates of the effect of MBS purchases on more exposed banks to be similar to the results in Table 5.

5.3. Heterogeneity across firms

A different concern is that firms and banks will match for specific reasons, some of which could make disentangling the effect of asset purchases on commercial lending and firm activity more difficult. In our sample, firms that are smaller in size, are lower in profitability, and have less tangible assets tend to match with banks that have higher MBS holdings. A similar pattern emerges for firms that borrow from securitizer banks compared with non-securitizers.[26]

To make sure these differences are not driving our results, we take the following steps. First, we control for persistent differences in firms and their relationships with particular banks by using firm-bank fixed effects in the appropriate specifications. Second, in our firm-level results, we interact time-varying firm characteristics with our measures of bank exposure to asset purchases. These interactions help control for differences in firm activity that can arise from firms matching with banks based on particular characteristics.

As an additional robustness check, we reproduce our main results regarding real effects at the firm level (Table 6) using a matched sample. This approach allows us to condition away some of the observed differences

[26] Online Appendix Table C.7 reports the differences in firm characteristics by type of bank.

Table 10
Firm investment, matched sample.

Columns 1 through 6 are panel fixed effect regressions. *Investment* is the firm's quarterly capital expenditures divided by lagged gross property, plant, and equipment, scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. "Additional firm interactions" include the firm variables (*Cash Flow, Lagged Tobin's q, Lagged Z-Score, Lagged Firm Size*) interacted with *High MBS Holdings, High Securities Holdings*, or *Securitizer* variables, depending on the specification. "Orthogonalized MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by firm and bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Investment, matched sample					
Variable	(1)	(2)	(3)	(4)	(5)	(6)
High MBS Holdings	0.107		0.104	−0.240		
	(1.059)		(1.173)	(0.261)		
High MBS Holdings × MBS Purchases	−0.0476***		−0.0506***	−0.0312**		
	(0.00770)		(0.0102)	(0.0120)		
Securitizer					0.0469	0.249
					(0.958)	(1.100)
Securitizer × MBS Purchases					−0.0441***	−0.0432***
					(0.0112)	(0.0127)
High Securities Holdings		−0.0257	−0.0111	−0.272*		−0.151
		(0.404)	(0.427)	(0.154)		(0.387)
High Securities Holdings × TSY Purchases		−0.00425	−0.00811	−0.0160		−0.0104
		(0.0165)	(0.0150)	(0.0133)		(0.0153)
Cash Flow	1.574***	0.833**	1.392***	0.571	1.350***	1.153***
	(0.284)	(0.341)	(0.293)	(0.403)	(0.325)	(0.362)
Lagged Tobin's q	0.144***	0.135***	0.136***	0.204***	0.164***	0.166***
	(0.0291)	(0.0284)	(0.0333)	(0.0200)	(0.0282)	(0.0239)
Lagged Z−Score	0.492***	0.303***	0.498***	0.201***	0.332***	0.433***
	(0.0885)	(0.110)	(0.0858)	(0.0418)	(0.0973)	(0.105)
Lagged Firm Size	−0.0366	−0.274	−0.0548	0.120	−0.0709	−0.0784
	(0.260)	(0.246)	(0.276)	(0.160)	(0.236)	(0.268)
Bank's Size	0.0393	−0.0171	0.0403	0.827***	0.0438	0.0296
	(0.228)	(0.252)	(0.226)	(0.297)	(0.241)	(0.240)
Bank's Equity Ratio	0.0249	0.0408	0.0262	−0.0163	0.0390	0.0403
	(0.0308)	(0.0330)	(0.0325)	(0.0359)	(0.0331)	(0.0346)
Bank's Net Income	−0.153**	−0.145	−0.144*	−0.0376	−0.157**	−0.151*
	(0.0737)	(0.0979)	(0.0802)	(0.0905)	(0.0751)	(0.0858)
Bank's Cost of Deposits	0.247	0.251	0.262	0.0177	0.221	0.201
	(0.167)	(0.159)	(0.159)	(0.175)	(0.167)	(0.164)
Bank's Cash to Assets	1.571	2.830**	1.536	−3.686*	2.073	1.793
	(1.536)	(1.226)	(1.471)	(1.918)	(1.624)	(1.590)
Bank's Loans to Deposits	−0.00474	−0.00645	−0.00483	−0.00963	−0.00590	-0.00569
	(0.00333)	(0.00387)	(0.00401)	(0.00742)	(0.00425)	(0.00495)
Change in Unemp. Rate, Bank's Counties	−0.0722	−0.0250	−0.0667	0.104	−0.0535	−0.0419
	(0.0796)	(0.0857)	(0.0832)	(0.0965)	(0.0848)	(0.0902)
Additional firm interactions	Yes	Yes	Yes	Yes	Yes	Yes
Orthogonalized MBS and securities holdings	No	No	No	Yes	No	No
Firm-bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm state by quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	42,669	42,669	42,669	27,439	42,669	42,669
Adjusted R^2	0.590	0.589	0.590	0.520	0.590	0.590

across firms to confirm that these differences are not driving our results. In Table 10, we match each firm observation for firms that borrow from a high-MBS bank with its nearest neighbor that borrows from a low-MBS bank. For the purposes of matching, we estimate the propensity score using a probit model with the firm's lagged size, lagged Tobin's q, and lagged Z-score as control variables. We allow matches with replacement. Across the specifications of Table 10, the estimates are similar in economic magnitude and statistical significance as in our full sample of borrowers of high-MBS and low-MBS banks in Table 6.

6. Constraints at the bank and firm level

The presence of constraints for firms and banks is an important component of the bank lending channel (Holmstrom and Tirole, 1997). Section 6.1 considers how asset purchases affect commercial lending growth depending on bank-level constraints. Section 6.2 compares more and less constrained firms and how their investment responds to asset purchases. Section 6.3 provides further evidence that the reduction in lending to firms is due to banks cutting lending and not due to firms demanding less credit.

Table 11
Commercial and industrial (C&I) loan growth and bank constraints.

Columns 1 through 4 are panel fixed effect regressions. *C&I Loan Growth* is the growth rate in C&I loans between the current and prior quarter, scaled by one hundred. The "more constrained" sample are those banks that are below the median by *Bank's Demand Deposits* and the "less constrained" sample are those banks that are above the median. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	C&I Loan Growth			
Variable	More constrained (1)	Less constrained (2)	More constrained (3)	Less constrained (4)
High MBS Holdings	−1.872**	0.541		
	(0.749)	(0.645)		
High MBS Holdings × MBS Purchases	−0.0867***	−0.00509		
	(0.0291)	(0.0298)		
Securitizer			2.300	1.869
			(1.542)	(1.823)
Securitizer × MBS Purchases			−0.373***	−0.204
			(0.107)	(0.180)
High Securities Holdings	1.939*	−0.823	2.218**	−0.875
	(1.008)	(0.760)	(1.006)	(0.755)
High Securities Holdings × TSY Purchases	0.0656	0.112***	0.0653	0.112***
	(0.0454)	(0.0423)	(0.0454)	(0.0423)
Bank's Size	−1.445***	−1.388**	−1.284**	−1.440**
	(0.549)	(0.580)	(0.548)	(0.571)
Bank's Equity Ratio	1.009***	0.739***	1.032***	0.735***
	(0.0922)	(0.0895)	(0.0939)	(0.0897)
Bank's Net Income	0.515***	0.512**	0.495***	0.518**
	(0.183)	(0.213)	(0.184)	(0.213)
Bank's Cost of Deposits	−1.227***	−0.448	−1.267***	−0.445
	(0.415)	(0.525)	(0.416)	(0.526)
Bank's Cash to Assets	0.0604*	0.0127	0.0734**	0.0116
	(0.0366)	(0.0267)	(0.0364)	(0.0266)
Bank's Loans to Deposits	−0.124***	−0.154***	−0.114***	−0.156***
	(0.0196)	(0.0195)	(0.0193)	(0.0189)
Change in Unemp. Rate, Bank's Counties	−0.380***	−0.324***	−0.382***	−0.324***
	(0.0892)	(0.0967)	(0.0891)	(0.0967)
Bank fixed effects	Yes	Yes	Yes	Yes
Quarter fixed effects	Yes	Yes	Yes	Yes
Number of observations	38,668	38,807	38,668	38,807
Adjusted R^2	0.101	0.0414	0.101	0.0414

6.1. Commercial lending and bank constraints

This paper argues that the negative C&I growth result is driven by the mortgage origination channel related to QE. Our argument requires us to show that the mortgage originating banks are responding to MBS purchases by increasing mortgage lending activity. The results from Section 3.1 provide evidence of this.

The banks also must be sufficiently constrained so that they needed to substitute away from other types of lending, and C&I lending in particular.[27] To test this, in Table 11, we split banks into more constrained and less constrained subsamples based on deposit financing (Ivashina and Scharfstein, 2010). If the bank is above the median bank in terms of demand deposits as a fraction of assets, we classify it as less constrained. Banks below the median bank in terms of access to demand deposit financing are considered more constrained.

The coefficient of the interaction term *High MBS Holdings × MBS Purchases* in Column 1 shows that when the Federal Reserve purchases MBS assets, banks with less access to demand deposit financing and high MBS holdings have statistically significantly lower C&I loan growth. Thus, constrained banks are reducing credit supply to firms in response to MBS purchases. Column 2 reports that less constrained banks with high MBS holdings do not significantly reduce their loan growth in respose to MBS purchases. The difference between the coefficients of the interaction terms in Columns 1 and 2 is statistically significant at the 10% level. Column 3 shows that banks that are high-MBS securitizers but have less access to demand deposit financing respond approximately four times more strongly to MBS purchases by reducing C&I loan growth (comparing the interaction coefficients of Columns 1 and 3). The less constrained securitizers also have a negative point estimate in Column 4, but the larger standard error leads to no statistical significance. The difference between more constrained and less constrained securitizers is also not statistically significant. This can suggest that even the securitizer banks with more demand deposits were

[27] Bernanke (1983), Khwaja and Mian (2008), Paravisini (2008), and Schnabl (2012) provide empirical evidence on financial constraints faced by banks and their effect on lending.

Table 12
Investment regression for firm constraints.

Columns 1 through 4 are panel fixed effect regressions. *Investment* is the firm's quarterly capital expenditures divided by lagged gross property, plant, and equipment scaled by one hundred. Dividing firms by size, "more constrained" firms are in the smallest tercile and "less constrained" firms are in the largest tercile. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Additional firm interactions" include the firm variables (*Cash Flow, Lagged Tobin's q, Lagged Z-Score, Lagged Firm Size*) interacted with *High MBS Holdings, High Securities Holdings*, or *Securitizer* variables, depending on the specification. Standard errors are clustered by firm and bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Investment			
Variable	More constrained (1)	Less constrained (2)	More constrained (3)	Less constrained (4)
High MBS Holdings	−3.091			
	(2.840)			
High MBS Holdings × *MBS Purchases*	−0.0876**	−0.0115*		
	(0.0445)	(0.00671)		
Securitizer			−1.733	
			(3.674)	
Securitizer × *MBS Purchases*			−0.0824***	−0.0136
			(0.0301)	(0.0109)
High Securities Holdings	1.054	1.673***	0.601	1.659***
	(1.440)	(0.588)	(1.460)	(0.567)
High Securities Holdings × *TSY Purchases*	−0.0289	−0.0124	−0.0350	−0.0160*
	(0.0243)	(0.00803)	(0.0257)	(0.00837)
Cash Flow	0.158	2.255***	−0.579	2.349***
	(0.508)	(0.309)	(0.753)	(0.352)
Lagged Tobin's q	0.124***	0.389***	0.152***	0.376***
	(0.0382)	(0.0324)	(0.0375)	(0.0356)
Lagged Z-Score	0.297***	0.278***	0.271***	0.284*
	(0.0952)	(0.0986)	(0.0718)	(0.147)
Lagged Firm Size	−0.305	1.249***	−0.710	1.132***
	(0.611)	(0.391)	(1.014)	(0.434)
Bank's Size	0.0984	−0.0512	0.119	−0.0459
	(0.309)	(0.263)	(0.271)	(0.256)
Bank's Equity Ratio	0.0287	−0.119***	0.0600	−0.106***
	(0.0642)	(0.0209)	(0.0632)	(0.0224)
Bank's Net Income	−0.0686	−0.193**	−0.0788	−0.196**
	(0.123)	(0.0956)	(0.110)	(0.0910)
Bank's Cost of Deposits	0.0546	−0.332	−0.0439	−0.391
	(0.268)	(0.278)	(0.287)	(0.308)
Bank's Cash to Assets	0.318	−3.545*	−0.373	−3.111
	(2.568)	(1.863)	(2.439)	(2.042)
Bank's Loans to Deposits	−0.00818	−0.00863**	−0.00973	−0.0113***
	(0.00617)	(0.00387)	(0.00906)	(0.00370)
Change in Unemp. Rate, Bank's Counties	−0.0417	0.135*	−0.0434	0.131
	(0.149)	(0.0778)	(0.156)	(0.0807)
Additional firm interactions	Yes	Yes	Yes	Yes
Firm-bank fixed effects	Yes	Yes	Yes	Yes
Firm state by quarter fixed effects	Yes	Yes	Yes	Yes
Number of observations	9,527	9,412	9,527	9,412
Adjusted R^2	0.506	0.614	0.507	0.613

sufficiently affected by the origination channel that the reduction in C&I lending was not confined to the more constrained securitizer banks.

Part of the reason for this reduction is that engaging in additional mortgage lending ties up what capital these more constrained banks have available. Even for banks that are originating mortgages with the sole purpose to quickly distribute them as MBS, Demyanyk and Loutskina (2016) estimate that, for more active banks, the temporary mortgage holdings would lead to 1% higher capital requirements. Ivashina and Scharfstein (2010) and Cornett et al. (2011) find that banks with less demand deposit financing are most likely to be constrained as alternative financing options became more scarce. For banks that cannot access additional financing, they understandably would cut back on other types of lending that carry larger capital requirements. As C&I loans generally carry a 100% risk weight, reducing new C&I lending is an effective way to offset the capital costs from new mortgage activity.

Considering this evidence, along with the evidence presented in Section 3, the origination channel drives up mortgage lending at the expense of C&I lending. The unintended negative consequence is most significant for the most constrained banks that are active in the mortgage market. Even for the less constrained banks, the net effect of the capital gains channel and the origination channel does not create a positive stimulus to commercial lending,

Table 13
Change in commercial and industrial (C&I) loan profitability.

Columns 1 through 6 are panel fixed effect regressions. *Change in C&I Loan Profitability* is the difference in the profitability of C&I loans for the current and prior quarter, scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Orthogonalized MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Change in C&I Loan Profitability					
Variable	(1)	(2)	(3)	(4)	(5)	(6)
High MBS Holdings	−0.238		−0.296	−0.601		
	(0.668)		(0.668)	(0.807)		
High MBS Holdings × MBS Purchases	0.101***		0.0978***	0.0873**		
	(0.0351)		(0.0353)	(0.0390)		
Securitizer					−0.549	−0.472
					(1.913)	(1.910)
Securitizer × MBS Purchases					0.377***	0.374***
					(0.135)	(0.135)
High Securities Holdings		0.759	0.851	0.703		0.772
		(1.015)	(1.020)	(1.235)		(1.015)
High Securities Holdings × TSY Purchases		−0.191***	−0.189***	−0.219***		−0.192***
		(0.0641)	(0.0640)	(0.0683)		(0.0641)
Bank's Size	1.366**	1.436**	1.484**	1.183*	1.276**	1.419**
	(0.573)	(0.583)	(0.589)	(0.674)	(0.564)	(0.583)
Bank's Equity Ratio	−0.324***	−0.321***	−0.327***	−0.445***	−0.321***	−0.323***
	(0.0979)	(0.0983)	(0.0984)	(0.107)	(0.0979)	(0.0984)
Bank's Net Income	−1.140***	−1.136***	−1.139***	−1.102***	−1.133***	−1.134***
	(0.233)	(0.234)	(0.234)	(0.276)	(0.234)	(0.234)
Bank's Cost of Deposits	−2.234***	−2.135***	−2.127***	−1.263**	−2.230***	−2.120***
	(0.523)	(0.524)	(0.525)	(0.598)	(0.523)	(0.524)
Bank's Cash to Assets	−0.0264	−0.0440	−0.0344	−0.0522	−0.0348	−0.0433
	(0.0304)	(0.0307)	(0.0309)	(0.0356)	(0.0302)	(0.0307)
Bank's Loans to Deposits	0.264***	0.260***	0.263***	0.252***	0.261***	0.260***
	(0.0201)	(0.0198)	(0.0204)	(0.0217)	(0.0195)	(0.0198)
Change in Unemp. Rate, Bank's Counties	0.527***	0.532***	0.531***	0.541***	0.527***	0.532***
	(0.139)	(0.139)	(0.139)	(0.160)	(0.139)	(0.139)
Orthogonalized MBS and securities holdings	No	No	No	Yes	No	No
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	76,584	76,584	76,584	63,250	76,584	76,584
Adjusted R^2	0.00807	0.00815	0.00822	0.00767	0.00801	0.00817

6.2. Constrained firms and asset purchases

The analysis so far has focused mainly on the heterogeneity among banks. For the reduction in firm investment to be driven by banks lessening commercial lending, the firms must face some capital constraints. Otherwise, these firms would simply move to another source of capital, such as another bank or public debt markets. Typically, sufficient frictions exist that firms are not able to fully substitute for lost capital (see, e.g., Faulkender and Petersen, 2006; Sufi, 2009; Leary, 2009; Chava and Purnanandam, 2011).

Table 12 divides firms by their likelihood of facing financing constraints based on size (Hadlock and Pierce, 2010).[28] In Columns 1 and 2, we split the firms based on firm size and interact the amount of MBS and Treasury purchases with the lending bank's exposure to the respective asset purchases. Column 1 reports the results for the smallest tercile of firms, and Column 2 reports the results for the largest tercile of firms. We find negative investment effects for smaller firms that borrow from banks with higher MBS holdings following MBS purchases. The effect on larger firms is smaller in magnitude. This is consistent with small firms, which are likely to be more constrained, being less able to replace lost capital from exposed banks and reducing investment as a result.

Columns 3 and 4 focus on the sample of firms that have a relationship with a high-MBS securitizer bank. Again, when the Federal Reserve purchases MBS, firms in the bottom tercile by size that borrow from securitizing banks face large real effects in terms of reduced investment (Column 3). Column 4 shows that firms in the top tercile by size that borrow from securitizer banks face a statistically insignificant effect. The point estimate is also smaller in magnitude. The difference in the effect between the two samples is significant at the 5% level.

The impact of Treasury purchases is weak in both categories when we split the sample by firm-level constraints. These result generally suggest that Treasury purchases do

[28] There is no estimated coefficient for *High MBS Holdings* or *Securitizer* in Columns 2 and 4, respectively, because none of these banks moves between the highest and lowest MBS terciles or securitizer and non-securitizer classifications in this sample. The variables are absorbed by the firm-bank fixed effect.

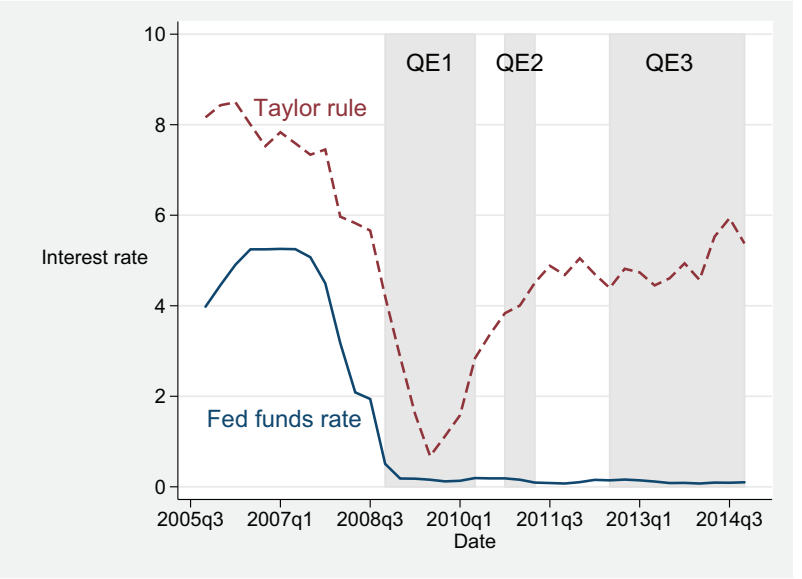

Fig. 2. Fed funds rate and Taylor rule. The figure plots the effective federal funds rate and the rate implied by the Taylor rule (Taylor, 1993). Data are from the Bank of St. Louis Federal Reserve's Economic Data (FRED; https://fred.stlouisfed.org/graph/?g=cN69). FRED measures the output gap as the difference between potential output (published by the Congressional Budget Office) and real gross domestic product (GDP). Inflation is measured by changes in the GDP implicit price deflator and the target inflation rate is 2%. FRED also assumes a steady-state real interest rate of 2%. Interest rate is in percentage points. QE1, QE2, and QE3 denote the first, second, and third round of quantitative easing, respectively.

not positively affect firm investment decisions and is in line with our investment results in Section 4.1.

6.3. Profitability of commercial lending and asset purchases

Section 3.2 addresses the concern that our results regarding the decrease in commercial lending are driven by a reduction in firm demand for credit. Another approach is to consider the profitability of commercial lending in response to MBS purchases. If MBS purchases crowd out commercial lending, then banks should ration the credit supply of the less profitable commercial loans (see, e.g., Stiglitz and Weiss, 1981). If firms demand less credit and the reduction in commercial lending is driven by lower firm demand, then the profitability of commercial lending should not increase in response to MBS purchases.

Table 13 reports the results. The dependent variable is the change in quarterly C&I profitability of a bank, in percentage points. Because this analysis is conducted at the bank level, the rest of the specification follows that used in Section 3.3. The coefficient of the interaction term in Column 1 suggests that banks in the top tercile of MBS holdings experience a higher increase in the profitability of commercial lending in response to MBS purchases than banks in the bottom tercile. Column 2 focuses on Treasury purchases. In this case, we find asymmetric results. The C&I profitability of banks with high securities holdings declines with Treasury purchases by the Federal Reserve. This result is consistent with the evidence in Section 3.3 that also suggests that higher Treasury purchases allow exposed banks to expand their credit supply. Column 3 includes both MBS and Treasury purchases and finds similar results to those in Columns 1 and 2. Column 4 utilizes the residual MBS and securities holdings that cannot be explained by other bank characteristics and uses these orthogonalized holdings as measures of the bank's exposure to asset purchases. Results remain similar to those reported for Column 3.

Because high-MBS securitizer banks are the biggest beneficiaries of the origination channel and reduce their commercial credit supply the most, we should expect them to experience stronger profitability gains. Column 5 suggests this is the case. Comparing the coefficients of Column 5 with those of Column 1, securitizing banks experience an approximately four times larger increase in C&I profitability for the same amount of MBS purchases. Column 6 includes Treasury purchases and finds similar results.

Taken together, banks that are more exposed to MBS purchases increase mortgage originations and decrease commercial lending, and the profitability of the remaining commercial lending increases as a result. This evidence, combined with the loan-relationship level evidence in Section 3.2 and constraint-based subsamples in Sections 6.1 and 6.2, is consistent with MBS purchases crowding out commercial lending and investment through the bank lending channel.

7. Additional discussion

This section provides additional results regarding the QE period. Section 7.1 discusses other monetary and fiscal stimulus actions that overlap with the Federal Reserve's asset purchases. Section 7.2 looks at how commercial lending is affected by asset purchases in the early and later parts of the QE period. Section 7.3 reports the change in the state-level mortgage origination market share of banks in response to MBS purchases as an alternative measure of mortgage lending. Section 7.4 investigates how mort-

Table 14
Commercial and industrial (C&I) loan growth and interest rates.

Columns 1 through 6 are panel fixed effect regressions. *C&I Loan Growth* is the growth rate in C&I loans between the current and prior quarter, scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Orthog. MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	C&I Loan Growth					
Variable	(1)	(2)	(3)	(4)	(5)	(6)
High MBS Holdings	−1.194**		−1.229**	−0.208		
	(0.599)		(0.602)	(0.927)		
High MBS Holdings × MBS Purchases	−0.0555***		−0.0516**	−0.0907***		
	(0.0208)		(0.0208)	(0.0328)		
Securitizer					4.428*	4.216
					(2.579)	(2.587)
Securitizer × MBS Purchases					−0.390***	−0.385***
					(0.0898)	(0.0894)
High Securities Holdings		−0.0741	−0.374	1.673***		−0.0868
		(0.705)	(0.713)	(0.615)		(0.705)
High Securities Holdings × TSY Purchases		0.113***	0.111***	0.0481		0.113***
		(0.0307)	(0.0307)	(0.0364)		(0.0307)
High MBS Holdings × Rate Stimulus	0.190*		0.227**	0.0798		
	(0.0997)		(0.101)	(0.181)		
Securitizer × Rate Stimulus					−0.587	−0.547
					(0.577)	(0.577)
High Securities Holdings × Rate Stimulus		0.0976	0.156	0.0286		0.0963
		(0.123)	(0.125)	(0.153)		(0.123)
Bank's Size	−1.771***	−1.874***	−1.925***	−2.177***	−1.671***	−1.851***
	(0.368)	(0.377)	(0.380)	(0.503)	(0.363)	(0.377)
Bank's Equity Ratio	0.908***	0.908***	0.903***	0.869***	0.918***	0.912***
	(0.0627)	(0.0626)	(0.0624)	(0.0863)	(0.0630)	(0.0627)
Bank's Net Income	0.569***	0.577***	0.579***	0.347*	0.562***	0.574***
	(0.140)	(0.140)	(0.140)	(0.192)	(0.141)	(0.140)
Bank's Cost of Deposits	−0.650**	−0.721**	−0.730**	−0.469	−0.663**	−0.735**
	(0.312)	(0.313)	(0.312)	(0.404)	(0.312)	(0.312)
Bank's Cash to Assets	0.0373*	0.0530***	0.0490**	0.0704**	0.0404**	0.0518**
	(0.0197)	(0.0202)	(0.0204)	(0.0288)	(0.0195)	(0.0202)
Bank's Loans to Deposits	−0.142***	−0.135***	−0.138***	−0.174***	−0.139***	−0.136***
	(0.0129)	(0.0127)	(0.0130)	(0.0164)	(0.0126)	(0.0127)
Change in Unemp. Rate, Bank's Counties	−0.329***	−0.335***	−0.333***	−0.417***	−0.332***	−0.335***
	(0.0669)	(0.0669)	(0.0669)	(0.0899)	(0.0669)	(0.0669)
Orthogonalized MBS and securities holdings	No	No	No	Yes	No	No
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	77,935	77,935	77,935	45,618	77,935	77,935
Adjusted R^2	0.0567	0.0568	0.0570	0.0708	0.0566	0.0569

gage rates offered by banks changed in response to MBS purchases during QE.

7.1. Lessons from concurrent events

Two important events during the QE period are the stimulus provided through low interest rates and the Troubled Asset Relief Program (TARP). TARP authorized the US Treasury to purchase illiquid assets from financial institutions. Duchin and Sosyura (2014) show that banks that received TARP assistance originated more and riskier mortgages. They do not find any evidence that corporate lending volume increased in response to TARP. In conjunction with the asset purchases of QE, the Federal Reserve provided monetary stimulus by keeping the federal funds rate low. We estimate the stimulus provided by this action. Fig. 2 reports the effective federal funds rate and the interest rate suggested by the Taylor rule. We consider the gap between the two rates as the net stimulus to the economy through the maintained federal funds rate.

We next conduct an exercise similar to that in Section 3.3 by interacting the new rate stimulus variable with different groups of banks. Table 14 reports the results. We find suggestive evidence that banks with higher MBS holdings provided more C&I lending due to stimulative interest rates. At the same time, the negative effect of MBS purchases on C&I lending persists and is similar to what we find in Table 5.

Because our paper focuses on the importance of the origination channel, the final two columns of Table 14 consider the high-MBS securitizer banks that are the most exposed to this channel. In these columns, we do not find that the rate stimulus led to more C&I lending. So, although we do find evidence of increased C&I lending for the broader measure of exposure based on MBS holdings, the high-MBS securitizer banks do not react to the stimu-

Table 15
Commercial and industrial (C&I) loan growth over the quantitative easing (QE) period.

Columns 1 through 3 are panel fixed effect regressions. *C&I Loan Growth* is the growth rate in C&I loans between the current and prior quarter, scaled by one hundred. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *High Securities Holdings* takes a value of one if the lending bank is in the top tercile by all non-MBS securities to total assets, and a value of zero if in the bottom tercile. *MBS Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve MBS purchases. *TSY Purchases* is the lagged quarterly log-dollar amount of gross Federal Reserve Treasury (TSY) purchases. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Orthogonalized MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	C&I Loan Growth		
Variable	(1)	(2)	(3)
High MBS Holdings	−0.446	−0.0610	
	(0.464)	(0.776)	
High MBS Holdings × MBS Purchases, through QE1	−0.101***	−0.149***	
	(0.0237)	(0.0412)	
High MBS Holdings × MBS Purchases, post-QE1	−0.0194	−0.0274	
	(0.0243)	(0.0404)	
Securitizer			2.055
			(1.360)
Securitizer × MBS Purchases, through QE1			−0.317***
			(0.108)
Securitizer × MBS Purchases, post-QE1			−0.346***
			(0.0849)
High Securities Holdings	0.265	1.754***	0.384
	(0.585)	(0.606)	(0.584)
High Securities Holdings × TSY Purchases, through QE1	0.000612	−0.0246	0.00538
	(0.0386)	(0.0471)	(0.0385)
High Securities Holdings × TSY Purchases, post QE1	0.172***	0.116***	0.167***
	(0.0315)	(0.0427)	(0.0313)
Bank's Size	−1.902***	−2.171***	−1.836***
	(0.378)	(0.495)	(0.375)
Bank's Equity Ratio	0.907***	0.871***	0.915***
	(0.0621)	(0.0862)	(0.0624)
Bank's Net Income	0.562***	0.330*	0.559***
	(0.139)	(0.192)	(0.140)
Bank's Cost of Deposits	−0.770**	−0.468	−0.772**
	(0.311)	(0.403)	(0.311)
Bank's Cash to Assets	0.0482**	0.0657**	0.0515**
	(0.0203)	(0.0285)	(0.0201)
Bank's Loans to Deposits	−0.140***	−0.175***	−0.137***
	(0.0130)	(0.0164)	(0.0127)
Change in Unemp. Rate, Bank's Counties	−0.334***	−0.418***	−0.337***
	(0.0669)	(0.0900)	(0.0669)
Orthogonalized MBS and securities holdings	No	Yes	No
Bank fixed effects	Yes	Yes	Yes
Quarter fixed effects	Yes	Yes	Yes
Number of observations	77,935	45,618	77,935
Adjusted R^2	0.0574	0.0711	0.0573

lus in a similar manner. This suggests that the origination channel dominates the other channels for the securitizer banks.

7.2. Commercial lending in different QE periods

In Section 3.3, we show that banks particularly exposed to the Federal Reserve's MBS purchases reduce their commercial loan growth. In Section 6.1, we further find that the effects are strongest for those banks that are the most constrained. A related question is whether the effects varied over the QE period. The banking sector as a whole was most constrained during the financial crisis and the period through QE1. While QE2 and QE3 were implemented to further improve economic conditions, the banking sector was no longer in as dire straits.

In Table 15, we split our main interaction variables into two parts: the effect of MBS and Treasury purchases through QE1 and the effect of MBS and Treasury purchases post-QE1. Column 1 presents the MBS and securities holdings terciles, and Column 2 presents the orthogonalized versions. For banks with high MBS holdings, the effect of MBS purchases is concentrated in the period through QE1. This is consistent with banks being, on average, more constrained during that period and therefore more likely to cut commercial lending when increasing mortgage lending to alleviate capital charges. The strongest effects for Treasury purchases on commercial lending appear after QE1. Although banks are benefiting from the capital gains channel across both periods, the banks did not actively convert those gains into more commercial lending through QE1.

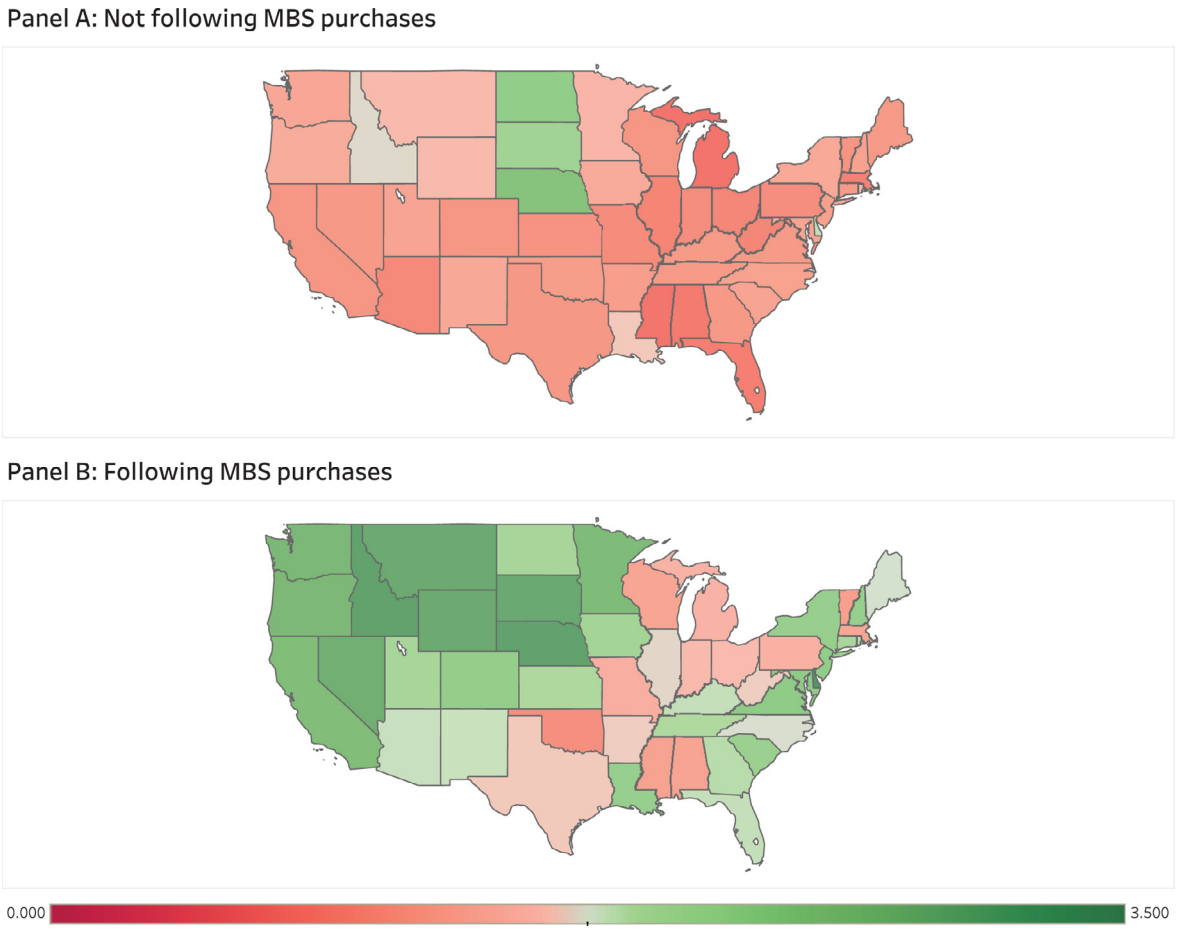

Fig. 3. Average state-level mortgage origination market share for securitizer banks, in percentage points. Panel A covers years not following fourth-quarter mortgage-backed security (MBS) purchases (2006, 2007, 2008, 2009, 2012). Panel B covers years following fourth-quarter MBS purchases (2010, 2011, 2013).

This could be because, from a capital requirements standpoint, Treasuries and other government agency debts carry a 0% risk weight. If banks were already constrained, selling these types of securities and increasing their commercial lending (which carries a 100% risk weight) would be particularly costly.

Column 3 of Table 15 looks at the effect of MBS purchases on high-MBS securitizer banks depending on the time period. In this case, both the period through QE1 and after QE1 show strong negative effects. The origination channel of QE is sufficiently strong for these particular banks such that, throughout the QE period, they see mortgage origination and MBS production as the focus of their additional lending activity at the continued expense of new commercial lending.

7.3. Mortgage lending market share

As an alternative measure for mortgage activity, we consider how the market share of banks changes in response to MBS purchases.[29] We investigate the change in mortgage origination market share of banks at a state level. This allows us to more finely control for differences in local economic conditions and confirm that our mortgage loan growth results are not driven by a particular region.

Fig. 3 shows the average market share at the state level for securitizer banks in years not following MBS purchases and years immediately following MBS purchases. For the securitizer banks, which are likely to be the most active in secondary mortgage markets, significant increases are evident in their average state-level market share following government MBS purchases. This effect is consistent across the majority of states.[30]

The specification for bank j active in state s in year t is

$$\begin{aligned} &\textit{Mortgage Origination Market Share}_{jst} \\ &= \alpha_j + \gamma_{st} + \beta_1 \textit{MBS Purchases}_{t-1} + \beta_2 \textit{Bank Exposure}_{jt-1} \\ &\quad + \beta_3 \textit{Bank Exposure}_{jt-1} \times \textit{MBS Purchases}_{t-1} \\ &\quad + \beta_4 \textit{Bank Variables}_{jt-1} + \epsilon_{jst}. \end{aligned} \tag{5}$$

[29] Recent papers that utilize market share in their analysis include Scharfstein and Sunderam (2016), Bord et al. (2017), and Cortés and Strahan (2017).

[30] Fig. C.1 in the Online Appendix repeats the analysis for the non-securitizer banks. In this case, no significant difference exists in average state-level market share in response to MBS purchases.

Table 16
Mortgage market share.

Columns 1 through 3 are panel fixed effect regressions. *Mortgage Origination Market Share* is the state-level market share (in basis points) for a given bank in a particular state and year. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *MBS Purchases* is the quarterly log-dollar amount of gross Federal Reserve MBS purchases from the fourth quarter of the prior year. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Orthogonalized MBS Holdings" refers to whether the MBS terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Mortgage Origination Market Share		
Variable	(1)	(2)	(3)
High MBS Holdings	−3.667	−4.770*	
	(2.598)	(2.538)	
High MBS Holdings × MBS Purchases	0.577***	0.352**	
	(0.203)	(0.153)	
Securitizer			−37.89
			(30.22)
Securitizer × MBS Purchases			4.620**
			(1.938)
Bank's Size	10.05***	5.990***	8.799***
	(3.257)	(1.953)	(3.032)
Bank's Equity Ratio	0.682	0.219	0.508
	(0.468)	(0.469)	(0.440)
Bank's Net Income	0.575	1.487	1.006
	(1.256)	(1.054)	(1.145)
Bank's Cost of Deposits	−6.696**	−4.749	−5.486*
	(2.964)	(3.403)	(2.811)
Bank's Cash to Assets	−0.434**	−0.385**	−0.380***
	(0.184)	(0.162)	(0.147)
Bank's Loans to Deposits	−0.102	−0.164	−0.0702
	(0.133)	(0.131)	(0.124)
Change in Unemp. Rate, Bank's Counties	−0.0507	−0.219	0.185
	(0.431)	(0.383)	(0.394)
Orthogonalized MBS holdings	No	Yes	No
Bank fixed effects	Yes	Yes	Yes
State by year fixed effects	Yes	Yes	Yes
Number of observations	45,332	38,561	45,332
Adjusted R^2	0.510	0.242	0.512

To control for local economic factors unrelated to MBS purchases, we include state by year fixed effects (γ_{st}) for each state where the bank has some market share. We also include bank fixed effects (α_j) to ensure that bank-specific time-invariant characteristics are not driving the changes in market share.

Table 16 reports the results. Column 1 shows that an increase in MBS purchases in the final quarter of the prior year leads to a gain in terms of MBS origination market share for a bank with high MBS holdings. As in previous sections, we refine the terciles of banks by MBS holdings using the orthogonalized MBS holdings and conduct a similar analysis. Column 2 reports the results. The coefficient point estimate drops, but the result remains statistically and economically significant. Banks with higher MBS holdings lend more in response to asset purchases. Column 3 focuses on the gain in market share of high-MBS securitizer banks following MBS asset purchases. Compared with Column 1, the effect is approximately eight times stronger in this case. Across all our specifications, we find that, in response to MBS purchases, benefiting banks increased their share of mortgage lending.

7.4. Rates for new mortgages

Supporting housing and mortgage markets was a stated objective of QE. Section 3.1 shows that MBS purchases led to more mortgage lending by the banks most exposed to these purchases. We now investigate if banks with higher MBS exposure offered lower rates to consumers.[31]

Here we consider two types of mortgage rates: the 15-year and the 30-year fixed rate mortgage. When looking at the specific types of MBS purchased by the Federal Reserve, about 8.4% were 15-year mortgages and 90.7% were 30-year mortgages.[32] The observation unit is at the bank-state-quarter level. Table 17 reports the results. Column 1 considers the impact of the Fed's MBS purchases on the 30-year fixed rate mortgage rates of banks with high MBS holdings. Column 2 orthogonalizes MBS holdings based on other bank characteristics, so that only the unexplained MBS holdings are used for the analysis. Column 3

[31] Related, Scharfstein and Sunderam (2016) investigate how the market power of banks affects the transmission of monetary policy.

[32] The remaining purchases (less than 1%) were 20-year MBS or the term information was not provided.

Table 17
Mortgage rates.

Columns 1 through 6 are panel fixed effect regressions. *Average 30-year Rate* is the average 30-year fixed mortgage rate (in basis points) for the bank in a specific state. *Average 15-year Rate* is the average 15-year fixed mortgage rate (in basis points) for the bank in a specific state. *High MBS Holdings* takes a value of one if the lending bank is in the top tercile by mortgage-backed securities (MBS) to total assets and a value of zero if in the bottom tercile. *MBS Purchases* is the quarterly log-dollar amount of gross Federal Reserve MBS purchases from the fourth quarter of the prior year. *Securitizer* takes a value of one if a high-MBS bank reported nonzero securitization income and zero otherwise. "Orthogonalized MBS and securities holdings" refers to whether the MBS and securities terciles have been orthogonalized to other bank characteristics. Standard errors are clustered by bank and are in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Average 30-year Rate			*Average 15-year Rate*		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
High MBS Holdings	29.77*	−36.60		5.151	−38.19	
	(17.42)	(27.06)		(23.74)	(25.05)	
High MBS Holdings × MBS Purchases	−1.505**	−0.370		−1.991***	−1.623***	
	(0.616)	(0.458)		(0.689)	(0.527)	
Securitizer			94.59***			76.30***
			(8.504)			(12.08)
Securitizer × MBS Purchases			−1.324***			−2.504***
			(0.459)			(0.712)
Bank's Size	12.30	15.28	18.54**	6.543	21.35**	15.18*
	(8.886)	(11.39)	(9.293)	(7.566)	(9.101)	(7.874)
Bank's Equity Ratio	−0.204	0.437	0.00214	−1.726	−1.407	−1.354
	(1.714)	(2.363)	(1.689)	(1.818)	(2.846)	(1.737)
Bank's Net Income	0.883	−4.179	0.559	2.156	−2.638	0.857
	(2.931)	(3.476)	(2.914)	(2.736)	(3.306)	(2.786)
Bank's Cost of Deposits	6.560	4.762	6.115	6.214	4.842	3.618
	(5.596)	(8.087)	(5.362)	(4.613)	(5.808)	(4.175)
Bank's Cash to Assets	0.793	0.860	0.883*	1.431**	1.049	1.578**
	(0.518)	(0.693)	(0.516)	(0.633)	(0.727)	(0.629)
Bank's Loans to Deposits	24.67	−4.340	17.24	54.83***	−11.96	45.56**
	(16.92)	(16.18)	(17.82)	(20.48)	(21.10)	(21.30)
Change in Unemp. Rate, Bank's Counties	−2.230**	−0.595	−2.096**	0.0406	0.715	−0.0500
	(0.985)	(1.027)	(0.970)	(1.122)	(1.526)	(1.123)
Orthogonalized MBS and securities holdings	No	Yes	No	No	Yes	No
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
State by quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	4,366	2,433	4,366	6,080	3,754	6,080
Adjusted R^2	0.921	0.934	0.922	0.914	0.927	0.915

considers the securitizing banks. Columns 4–6 repeat the analysis for 15-year fixed rate mortgages. Across all specifications, we include bank fixed effects, state by quarter fixed effects, and the set of bank control variables used elsewhere in the paper.[33]

Column 1 reports that banks with higher MBS holdings offered a lower rate in response to MBS purchases. Column 2 reconducts the analysis using the MBS holdings for each bank orthogonalized with respect to other bank characteristics and finds a negative but not statistically significant result. Column 3 finds that high-MBS securitizing banks also lowered their average interest rate following MBS purchases. For 15-year fixed rate mortgages, Columns 4–6 report results similar in magnitude to those in Columns 1–3. On average, MBS purchases led to lower interest rates for individuals who borrowed from the more exposed banks.

[33] We require that the quoted mortgage rate does not include points or other specialized terms and is for a typical 20% down payment. As contracts that include points, lower down payments, or other special features are more prevalent in 30-year mortgages than 15-year mortgages, this helps explain the lower observation count for 30-year mortgages. In unreported analysis, we find that including mortgage rates with points (using a rate adjustment factor of 25 basis points per mortgage point) or including mortgage rates that allow smaller down payments do not significantly affect the results.

8. Conclusion

Much research focuses on the negative effects of large downturns in the economy and the benefits of monetary policy support. In this paper, we consider the impact of quantitative easing on bank lending and firm investment.

We find that banks that benefit from MBS asset purchases increase mortgage lending. An important unintended consequence is that these banks reduce commercial lending. The reduced lending has real effects. Firms that borrow from these banks decrease investment as a result. Treasury purchases do not lead to the same response. A separate finding is that the positive impact of Treasury purchases during quantitative easing through the bank lending channel on private investment seems to be small.

Policy makers have argued for the need to support important asset markets to increase consumer wealth, consumer demand, and real economic activity. When considering intervention in certain asset markets, such as the housing and Treasury markets, the potential asymmetric effects on banks and firms are important to consider.

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