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Quantitative Easing and Financial Risk Taking: Evidence from Agency Mortgage REITs*

W. Scott Frame[†] and Eva Steiner[‡]

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Abstract

An emerging literature documents a link between central bank quantitative easing (QE) and financial institution *credit* risk-taking. This paper tests the complementary hypothesis that QE may also affect *financial* risk-taking. We study Agency MREITs – levered shadow banks that invest in guaranteed U.S. Agency mortgage-backed securities (MBS) principally funded with repo debt. We show that Agency MREIT growth is inversely related to the Federal Reserve’s Agency MBS purchases, reflecting investor portfolio rebalancing. We also find that these institutions increased leverage during the later stages of QE, consistent with “reaching for yield” behavior. Agency MREITs seem to concurrently adjust their liquidity and interest rate risk profiles.

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1 Introduction

Following the global financial crisis and into the Great Recession, the Federal Reserve reduced its overnight interest rate effectively to the zero lower bound and engaged in large-scale purchases of long-term U.S. Treasury and Federal Agency MBS.¹ Several empirical studies demonstrate that quantitative easing (QE) lowered long-term interest rates for U.S. Treasury securities and Agency MBS as intended.² However, as U.S. monetary policy accommodation lingered, some policymakers and pundits grew concerned about the emergence of financial stability risks. For example, former Federal Reserve Chairman Bernanke (2013) noted that “maintaining low interest rates for too long may create incentives for market participants to take on greater duration or credit risks, or to employ additional financial leverage,” in an effort to “reach for yield.”³ Consistent with this concern, Chodorow-Reich (2014), DiMaggio and Kacperczyk (2016), and Choi and Kronlund (2018) provide empirical evidence of heightened risk taking by U.S. non-bank financial institutions during the Federal Reserve’s QE.⁴ However, each of these studies focuses exclusively on *credit* risk-taking in terms of the investment choices made by money market funds, pension funds, and corporate bond funds.

In this paper, we test the complementary hypothesis that QE influences financial institution risk-taking through their *financing* choices. To do so, we study Agency Mortgage REITs (Agency MREITs), which are shadow banks that focus on investments in mortgage-backed securities (MBS) guaranteed by one of the U.S. government agencies (Fannie Mae, Freddie Mac, and Ginnie Mae). Agency MREIT portfolios are financed by broker-dealers predominantly using short-term repurchase agreements and with collateral haircuts establishing permissible leverage. Given their investment focus, Agency MREIT assets are not subject to credit risk. However, these institutions are exposed to significant solvency, interest rate, and liquidity risks, arising from funding long-term callable bonds with short-term liabilities. This simple structure allows us to effectively shut off any QE-induced response in terms of credit risk-taking and conduct a clean test of the hypothesis that financial institutions respond to QE through their capital structure choices.

¹ From the start of 2008 through the end of 2017, the Federal Reserve’s balance sheet grew from \$0.9 trillion to \$4.5 trillion and was then principally comprised of long-term U.S. Treasury notes and bonds (\$2.5 trillion) and Federal Agency mortgage-backed securities (\$1.8 trillion). Federal Reserve balance sheet information is available weekly from the Federal Reserve Statistical release under <https://www.federalreserve.gov/releases/h41/> (H.4.1. Factors Affecting Reserve Balances).

² See Gagnon, Raskin, Remache, and Sack (2011); Hancock and Passmore (2011); Krishnamurthy and Vissing-Jorgensen (2011); Neely (2012); Hamilton and Wu (2012); D’Amico and King (2013); and Bauer and Rudebusch (2014).

³ While heightened risk taking is seemingly an intended consequence of unconventional monetary policy, recent theoretical research points to it being potentially distorted by agency problems associated with delegated asset management (e.g., Rajan 2005; Feroli, Kashyap, Schoenholtz, and Shin 2014; Acharya and Naqvi 2019; Morris and Shin 2016). Specifically, very low interest rate environments increase asset managers’ sensitivity to relative fund performance, which induces them to take on more risk than would otherwise be the case.

⁴ This research is part of a broader literature describing a “risk taking channel” of monetary policy, distinct from the interest rate and credit channels (e.g., Adrian and Shin, 2010; Borio and Zhu, 2012). Empirical analyses of bank behavior suggest that they make *ex ante* riskier loans as monetary policy becomes more accommodative (Jimenez, Ongena, Peydro, and Saurina, 2014; Ioannidou, Ongena, and Peydro, 2015; Dell’Ariccia, Leaven, and Suarez, 2017; Bonfim and Soares, 2018). Related research finds that accommodative monetary policy is associated with tighter yield spreads for U.S. corporate loans – particularly for the riskiest borrowers (Delis, Hasan, and Mylolonidis, 2017; Paligorova and Santos, 2017).

Agency MREITs experienced a surge in total assets from \$79.2 billion to \$363.5 billion (equivalent to 459% growth) during QE1 and QE2, followed by a sharp decline during QE3 and Tapering. During all QE regimes, Agency MREITs issued and repurchased stock to adjust the size of their balance sheets to market conditions. This behavior demonstrates how the Federal Reserve's activity in the Agency MBS market affected investment opportunities for Agency MREITs. Looking ahead, as the central bank withdraws from the Agency MBS market, Agency MREITs may emerge as an important investor class. However, the U.S. Financial Stability Oversight Council (2013) warns about financial stability risks emanating from these institutions, given their reliance on maturity transformation without access to government liquidity backstops. This current policy concern is an additional motivating factor for our analysis of the financial risk profile of Agency MREITs.

To identify the effects of QE on institution-level outcomes, we employ a cross-sectional comparison between Agency MREITs and Non-Agency MREITs. Non-Agency MREITs constitute a natural control group since they are subject to the same statutory requirements as Agency MREITs but hold a broader portfolio of mortgage-related assets. As a result, we expect Agency MREITs to be more sensitive to the Federal Reserve's posture in the Agency MBS market than Non-Agency MREITs. Our empirical approach is similar to that taken in Rodnyansky and Darmouni (2017) and Chakraborty, Goldstein, and MacKinlay (2020), both of whom examine lending responses to QE across U.S. commercial banks with differential exposure to the Agency MBS market.

We begin by conducting a high-frequency event study of equity market reactions by Agency and Non-Agency MREITs to QE-related central bank communications. Federal Reserve announcements of large-scale purchases of Treasury and Agency MBS during QE1 had a positive cumulative effect on both types of MREITs, reflecting an increase in legacy asset values that raised net worth. We further show that Agency MREITs benefitted relatively less from these announcements than Non-Agency MREITs (2.2% cumulative increase in equity prices for Agency MREITs versus 4.0% for Non-Agency MREITs), likely owing to the negative convexity profile of Agency MBS. We document that the announcements regarding QE2, which was limited to Treasury purchases, benefitted Agency MREITs and Non-Agency MREITs to a similar degree. We also find that Agency MREITs reacted significantly more negatively than Non-Agency MREITs to the announcements around the so-called Taper Tantrum (−2.5% versus −1.1% cumulatively). These communications unanchored market expectations about future policy rates previously tied down by the Federal Reserve's forward guidance. Agency MREITs likely showed a stronger reaction to the prospect of rising interest rates due to their heavy reliance on short-term debt. Our results expand on prior evidence for life insurers, banks, and the stock market presented in Chodorow-Reich (2014).

Next, we turn to an analysis of Agency MREIT asset growth, equity issuance, and stock repurchases over the 2005:Q1—2015:Q4 period. Conditioning on macroeconomic fundamentals, institution characteristics, and Federal Reserve purchase activity in the Treasury market, we find that Agency MREIT asset growth responded negatively to the Federal Reserve's quarterly purchase share of newly issued Agency MBS during that time. We estimate that a one-standard deviation increase in the Federal Reserve's purchase share of Agency MBS was associated with a reduction in Agency MREIT asset growth by 3.6 percentage points per quarter, or approximately 40% of the

unconditional mean. These results are predominantly driven by the central banks' Agency MBS purchases during the Tapering period. We document consistent evidence for Agency MREIT equity issuance (share repurchases), reflecting investor portfolio rebalancing toward (away from) Agency MREITs in response to variation in their investment opportunities. Collectively, our results show how the central banks' activity in the Agency MBS market crowds out private-sector investment and induces portfolio rebalancing by equity investors in Agency MREITs.

We then test whether Agency MREITs altered their financing choices in response to QE and the associated variation in investor demand for their shares. We first show that the Federal Reserve's purchase share of Agency MBS during the later stages of QE was associated with a significant decline in Agency MREITs' equity-to-assets ratio (i.e., increased leverage). Importantly, this result is obtained after controlling for cash holdings (a measure of internal liquidity), total accumulated other comprehensive income (an external source of variation in equity), fixed-rate Agency MBS holdings (a proxy for interest rate risk exposure), and use of derivatives (a measure of interest rate risk hedging). In economic terms, our estimates suggest that a one-standard deviation increase in the Federal Reserve's purchase share of Agency MBS during QE3 and was associated with a decline in the equity-to-assets ratio of 1.7 percentage points, or more than 12% of the unconditional mean. We also find that Agency MREITs reduced their share of very short-term repo debt (< 30 days) in response the central banks' Agency MBS purchases later in the QE cycle, although this was seemingly offset by an increase in their interest rate risk exposure. Taken together, our results represent novel evidence on the effect of QE on financial institution risk-taking in terms of their capital structure choices and is consistent with "reaching for yield" behavior.

We contribute to the emerging literature on QE-induced risk-taking by financial institutions. Chodorow-Reich (2014) provides evidence that money market funds with higher expenses reached for higher returns between 2009 and 2011; and that some private defined-benefit pension funds increased their risk taking around the same time. DiMaggio and Kacperczyk (2017) find that money market funds invested in riskier asset classes during QE. Choi and Kronlund (2018) study corporate bond funds and find that these institutions generate higher returns and attract more inflows when they reach for yield during periods of low interest rates, although these yields tend to be negative on a risk-adjusted basis. We find that Agency MREITs increased their leverage in response to variation in the Federal Reserve's purchase share of Agency MBS in the later stages of QE, while concurrently adjusting their debt maturity and interest rate risk profiles. Our results thus complement the existing literature, which focuses exclusively on credit risk-taking, by providing novel evidence for QE-induced risk-taking by financial institutions through their capital structure choices.

We also contribute to the recent literature linking QE to the investment decisions of financial institutions. Joyce et al. (2017) report that U.K. insurance companies and pension funds shifted allocations from government bonds to corporate bonds in response to the Bank of England's QE. Chakraborty, Goldstein, and MacKinlay (2020) find that U.S. banks with a high portfolio concentration of Agency MBS increased their mortgage originations and decreased their holdings of commercial loans (relative to other banks with low Agency MBS concentrations) in response to the Federal Reserve's Agency MBS purchase activity. Rodnyansky and Darmouni

(2017) show that U.S. commercial banks with greater Agency MBS holdings expanded their mortgage lending (and ultimately total lending) during QE1 and QE3. Di Maggio, Kermani, and Palmer (2018) present evidence of a relationship between QE and mortgage refinancing activity for loans eligible for purchase by the Federal Reserve. Kandrac and Schlusche (2017) link increased central bank reserves to expanded lending by U.S. banks during QE. We illustrate how the Federal Reserve’s Agency MBS purchases altered the investment opportunities of Agency MREITs. We expand on this prior work by showing that the central banks’ purchase activity was positively related to Agency MREIT share repurchases, with investors redeeming shares to rebalance portfolios and deploy capital elsewhere. Our results also complement those by DiMaggio and Kacperczyk (2016) for the money fund industry.

Our study further relates to the debate on the channels through which QE influences long-term interest rates.⁵ The “signaling” and “portfolio balance” channels are the most widely discussed. Under the signaling channel large-scale asset purchases by the central bank act as a commitment device to a low interest rate policy, which lowers the expected level of future short-term interest rates, similar to forward guidance (e.g., Clouse et. al, 2003; Eggertsson and Woodford, 2003; Bauer and Rudebusch, 2014). Under the portfolio balance channel, large-scale asset purchases reduce the amount of long-term, low-risk bonds in private-sector portfolios and thus lower the term (risk) premium in long duration assets (e.g., Bernanke, 2010). Most recent studies into the response of various types of financial institutions to QE are inherently about the portfolio balance channel. The evidence we present for central bank activity in the Agency MBS market crowding out private investment is consistent with this view.

Lastly, our analysis speaks to the future composition of Agency MBS investors. The Federal Reserve became the largest holder of Agency MBS after QE but has launched a balance sheet normalization plan to reduce its footprint in this market. Prior to the global financial crisis, Fannie Mae and Freddie Mac had collectively been the largest holders of Agency MBS, although their role markedly receded after the two institutions were placed into federal conservatorship.⁶ This creates an opening for private-sector, non-bank investment in Agency MBS. Our results documenting the rapid expansion of Agency MREITs suggest that these institutions could become a prominent investor class in the future and may assume the role of the marginal price-setting investor.⁷

We proceed as follows. Section 2 outlines salient features of the institutional background in the Agency and Non-Agency MREIT sectors and of the central banks’ QE program to develop testable hypotheses. Section 3 presents details on data collection and sample characteristics. Section 4 documents the results of the event study. In Section 5, we discuss our findings on the empirical association between QE and Agency MREIT growth. Section 6 presents the results on QE and Agency MREIT financial risk-taking. Section 7 concludes the paper.

⁵ See Krishnamurthy and Vissing Jorgensen (2011) for an overview of the various channels proposed in the literature.

⁶ The “retained portfolios” at Fannie Mae and Freddie Mac provided little social value (Passmore 2005), led to a build-up of systemic risk (Eisenbeis, Frame, and Wall, 2007), and were a primary factor in the timing of the federal takeover (Frame, Fuster, Tracy, and Vickery, 2015). Hence, most reform proposals would place permanent limitations on such holdings.

⁷ Gabaix, Krishnamurthy, and Vigneron (2007) show that the marginal investor in the Agency MBS market is indeed like to be a specialized arbitrageur, not a diversified representative investor as hypothesized by traditional asset pricing models.

2 Institutional Background

The analysis in this paper relies on the institutional features of the U.S. mortgage REIT market as well as the timeline and nature of the quantitative easing (QE) program implemented by the Federal Reserve in response to the global financial crisis and the subsequent recession. Here we outline relevant institutional features of mortgage REITs and provide a summary of the Federal Reserve's QE actions to develop testable hypotheses.

2.1 *Mortgage REITs*

Real estate investment trusts (REITs) are specialized investment vehicles that hold real estate-related assets. REITs are exempt from specific provisions of the Investment Company Act, which implies that they are not subject to prudential regulation, including leverage limits. A REIT may be a public company registered with the U.S. Securities and Exchange Commission or privately held. A public REIT may be listed on an exchange or be unlisted and have shares sold directly to investors by broker-dealers. As long as REITs distribute at least 90% of their taxable net income annually, they are exempt from federal corporate income tax. To the extent that such distributions are in the form of dividends, these profits are taxed at the shareholder's ordinary income tax rate and hence avoid double-taxation. The high level of mandatory dividend distributions implies that REITs fund growth by raising new (equity) capital, rather than through retained earnings. REITs generally specialize in either owning real estate assets or providing debt financing for them. Equity REITs own properties and typically focus on specific geographies and/or property types. By contrast, mortgage REITs invest in whole mortgage loans and/or mortgage-backed securities that are secured by residential and/or commercial properties.⁸

As shown in Figure 1, based on the Federal Reserve's Flow of Funds data, a large share of MREIT investment is in Agency MBS guaranteed by either Fannie Mae, Freddie Mac, or Ginnie Mae. Fannie Mae and Freddie Mac are U.S. government-sponsored enterprises (GSEs) that securitize "conforming" residential mortgages. Since the financial crisis these two institutions have enjoyed "effective" federal backing of all obligations (see, e.g., Frame, Fuster, Tracy, and Vickery, 2015). Ginnie Mae is a government agency within the U.S. Department of Housing and Urban Development (HUD), created exclusively to securitize government-insured mortgages. All three institutions provide blanket guarantees on their MBS in exchange for guarantee fees (i.e., insurance premiums) from mortgage originators. While Agency MBS are viewed as effectively having no credit risk, these instruments are very long-term and subject to significant prepayment risk arising from borrower refinancing due to changes in interest rates and routine housing turnover.

⁸ Other important REIT rules include: (i) maintaining at least 75% of total assets in qualifying real estate assets and cash; (ii) receiving at least 75% of income from some combination of rent from real property, interest from mortgages securing real property, gains from the sale of real property, and distributions from other REITs; (iii) receiving at least 95% of income from the aforementioned qualified real estate sources or from certain other passive sources; (iv) deriving less than 30% of gross income from the sale or other disposition of stock or securities held for less than six months, and real property held for less than four years; and (v) issue transferrable shares held by at least 100 individuals with no five or fewer owning more than 50% during the last half of the taxable year.

[Figure 1 about here.]

Using institution-level data from S&P Global, Panel A of Figure 2 shows that total MREIT investment in Agency MBS is concentrated in a subset of specialized MREITs. These so-called Agency MREITs are identified as holding, on average, at least 50% of total assets in Agency MBS. Agency MREITs' actual portfolio shares average 90%. During the early 2000s, there were only three Agency MREITs of note; namely, Annaly Capital Management, Anworth Mortgage Asset Corporation, and Capstead Mortgage Corporation. Following the onset of the global financial crisis, as many as 14 Agency MREITs were in operation (Panel B).

[Figure 2 about here.]

Agency MREITs grew markedly during the Federal Reserve's QE programs. This dramatic expansion, coupled with their potentially fragile business model relying on little equity and large amounts of (short-term) repo debt, caught the attention of the newly created Financial Stability Oversight Council in 2013. Policymakers were concerned about the vulnerability of these shadow banks to sharp increases in interest rates that would erode the value of their assets, potentially resulting in a run on their short-term liabilities and a large-scale sell-off in the Agency MBS market. Despite these conjectures, a systematic empirical analysis of Agency MREIT growth and risk taking in the context of QE is absent from the literature. This issue may be of ongoing policy interest as the central bank exits the Agency MBS market under its "portfolio normalization plan." The recent evidence of rapid Agency MREIT expansion suggests that these institutions could play a significant role in the Agency MBS market going forward, especially given the post-conservatorship shrinkage of such holdings by Fannie Mae and Freddie Mac.

2.2 *Timeline and Nature of the Federal Reserve's Quantitative Easing Program*

The first round of quantitative easing (QE1) implemented by the Federal Reserve was announced in 2008:Q4 and ran through 2010:Q1. It included the purchase of \$1.25 trillion in Agency MBS, \$300 billion of U.S. Treasury securities, and \$200 billion of Agency debt. QE2 was a short-lived program (2010:Q4—2011:Q2) that involved the central bank purchasing an additional \$600 billion in U.S. Treasury securities but no more Agency MBS. This was followed by the Maturity Extension Program (2011:Q3—2012:Q4), which included the purchase of another \$400 billion in very long-term U.S. Treasury securities (6–30 years) and the sale of similar amounts of short-term securities in an effort to "twist" the yield curve. The Federal Reserve also began principal reinvestments of proceeds from their Agency MBS portfolios back into similar assets. During this period, the Federal Reserve began ratcheting up its use of "forward guidance" to anchor expectations of the very short-term policy rate at the effective zero lower bound for up to two years out. QE3 (2012:Q3—2013:Q4) saw a renewal of Federal Reserve purchases of

Agency MBS and the continuation of long-term U.S. Treasury purchases. During the Tapering regime (2013:Q4—2014:Q3), the Federal Reserve continued, but gradually slowed, the pace of long-term asset purchases.⁹

The Federal Reserve’s large-scale purchases of Agency MBS during QE was novel. Prior to the global financial crisis, Fannie Mae and Freddie Mac were large holders of Agency MBS, although their role significantly receded after the two institutions were placed into federal conservatorship.¹⁰ Figure 3 presents the Agency MBS purchases completed by the Federal Reserve and Fannie Mae/Freddie Mac as a share of newly issued securities (Panel A) and Federal Reserve and Fannie Mae/Freddie Mac Agency MBS holdings as a share of the total volume of securities outstanding (Panel B). Panel A of Figure 3 shows that the Federal Reserve absorbed 86% of new issuance in 2009:Q1 before halting purchases one year later. The central bank renewed its Agency MBS purchases in 2011:Q4. This was initially limited to related principal reinvestments to maintain portfolio size, but later expanded during QE3. Purchase amounts subsequently declined during the Tapering period, starting in 2013:Q4. Fannie Mae and Freddie Mac collectively ramped up purchases of Agency MBS during 2008, before reducing them during QE1. Thereafter, the two GSEs together maintained a mean quarterly purchase share of Agency MBS around 10% of new issuance. Panel B of Figure 3 shows the share of Agency MBS outstanding held by the Federal Reserve and Fannie Mae/Freddie Mac. Over the 2008—2015 period, the central bank increased its share from zero to over 30%. The GSEs’ share of aggregate Agency MBS investment declined from about 16% to 4%, as the terms of the U.S. Treasury’s financing for the conservatorships required that these portfolios shrink.

[Figure 3 about here.]

2.3 *Testable Hypotheses*

Our analysis explores Agency MREIT growth and financial risk-taking during QE. Agency and Non-Agency MREITs provide a useful cross-sectional comparison since Non-Agency MREITs are subject to the same statutory requirements as are Agency MREITs, but they invest in a broader range of mortgage-related assets. The Federal Reserve’s purchases in the Agency MBS market purposely curtail investment opportunities for other investors as per the QE “portfolio balance channel.” Given Agency MREITs’ singular investment focus, we expect their growth should be negatively related to the depth of Agency MBS purchase activity by the Federal Reserve during QE1, QE3, and the Tapering. Conversely, we would expect Agency MREITs to grow significantly larger during QE2 when the central bank halted purchases. As a result of Agency MREITs’ specialization on Agency MBS investments we expect their asset growth rates to be more sensitive to the Federal Reserve’s posture in the Agency MBS market than their Non-Agency counterparts.

⁹ Appendix A provides a comprehensive timeline of the Federal Reserve’s QE program, based on the published minutes from the Federal Open Market Committee meetings.

¹⁰ Holdings by foreign central banks also declined significantly with the onset of the crisis.

Central bank asset purchases act to reduce long-term interest rates, flatten the yield curve, and thus compress intermediation margins. In order to maintain target returns, investors engaged in long-short carry trades would naturally attempt to lower their cost of capital by increasing leverage and/or increasing their duration gap by shortening debt maturity and reducing hedging activity. For Agency MREITs, we expect this behavior to be especially pronounced during the period in which the Federal Reserve is purchasing a large share of new Agency MBS issuance and limiting Agency MREIT growth opportunities.

3 Data

Our primary data source is S&P Global, which includes quarterly information about MREIT balance sheets, income statements, and capital market activities. The study period is 2005:Q1—2015:Q4. We start in 2005 due to data limitations but lose little relevant information as there were only three Agency MREITs prior to that year.

For each MREIT in S&P Global, we obtain quarterly financial reporting data for total assets, total Agency MBS, total cash and cash equivalents, total equity, total repo debt, repo debt due in 0-30 days, and total accumulated other comprehensive. We also collect data on the number of shares outstanding and the share price at the end of each quarter to compute the market-to-book value of equity. We further obtain information on whether an MREIT issued equity and repurchased shares in a given quarter, as well as the amounts issued or repurchased. Finally, we hand-collect quarterly data on the type of Agency MBS holdings in terms of fixed-rate versus variable-rate securities and derivative positions for interest rate swaps and swaptions from MREIT 10-K and 10-Q reports. As these variables are not required reporting items, this information is only available for a sub-set of institutions. We are able to obtain information on the type of Agency MBS held for 26 institutions and data on derivative usage for 25 institutions. We identify Agency MREITs by computing the ratio of Agency MBS to total assets for each institution-quarter over the study period and classify institutions as Agency MREITs if that ratio exceeds 50% on average. Our results are robust to defining Agency MREITs based on a range of alternative threshold values.

Based on the data collected, we construct the following set of institution characteristics. *Total Assets* is the book value of total assets, in \$ billion. *Growth in Assets* is the quarterly rate of growth in total assets. *Agency MBS/Assets* is the total amount of Agency MBS held, scaled by total assets. *Issued Equity* is an indicator that takes the value of one if an institution issued equity in a given quarter. *Amount Issued* is the total amount of equity issued in a given quarter, scaled by total assets at the beginning of the quarter. We define *Repurchased Shares* as an indicator that takes the value of one if an institution repurchased shares in a given quarter. *Number Repurchased* is the number of shares repurchased in a given quarter, scaled by the number of shares outstanding at the beginning of the quarter. *Market-to-Book Value* is the ratio of the market value of equity, obtained as the product of the number of shares outstanding multiplied by the end-of-quarter share price, scaled by the book value of equity. We define *Equity/Assets* as a proxy for institution leverage using the ratio of book equity to total assets. *AOCI/Assets* is the ratio of total accumulated other comprehensive income to total assets. *Cash/Assets* is the ratio of cash and cash-equivalent securities to total assets. *Repo Debt/Assets* is the ratio of repo debt to total assets. We also consider institution exposure to short-term

repo, proxied by the ratio of repo debt maturing within 0-30 days to total repo, and denoted *Repo (0-30)/Total Repo*. We compute *Fixed-Rate MBS/Agency MBS* as the ratio of fixed-rate Agency MBS to total Agency MBS. We proxy for interest rate risk hedging activity using the ratio of swaps plus swaptions to total liabilities, or *Swaps & Swaptions/Liabilities*.

We further collect data for three interest rate variables that capture the principal drivers of the profitability of Agency MBS investment. The 3-month and 10-year constant maturity Treasury rates are obtained from the Federal Reserve Bank of St. Louis. Based on those rates, we construct measures of the level (*3-Month CMT*) and slope of the U.S. Treasury yield curve (10-year CMT less 3-month CMT, denoted *CMT Term Structure*). The option-adjusted mortgage spread (*OAS*) measures the attractiveness of Agency MBS investment relative to long-term Treasury bonds. We use Bloomberg Barclay's US MBS Fixed Rate Average OAS as a proxy.¹¹ We also collect data for two variables that are related to the credit-sensitive mortgage investments held by Non-Agency MREITs. The first is the quarterly spread between Moody's Seasoned Baa Corporate Bond yield and the yield on the 10-year CMT (*Credit Spread*). The second is the quarterly growth rate in the *Case-Shiller HPI*.

We supplement the macroeconomic data outlined above with quarterly information from the Federal Reserve Bank of New York on the central banks' actual quarterly purchases and holdings of Agency MBS and Treasury securities in the course of the QE program, as well as the total amount of these securities issued and outstanding. We compute the *Fed MBS (Treasury) Purchase Share* as the amount of MBS (Treasury) purchases relative to MBS (Treasury securities) issued. Lastly, we compute the *Fed MBS (Treasury) Holdings Share* as the amount of MBS (Treasury securities) held relative to total MBS (Treasury securities) outstanding.

3.1 Descriptive Statistics

Table 1 presents sample statistics for 1,002 institution-quarter observations from our final sample of 15 Agency MREITs and 35 Non-Agency MREITs over the 2005:Q1—2015:Q4 period. Agency MREITs are larger on average than Non-Agency MREITs (\$18.0 billion versus \$4.3 billion in total assets). Agency MBS account for 84% of Agency MREIT total assets but only 6% for Non-Agency MREITs. Agency MREITs issue equity in 26% of the quarters, with the mean amount issued per quarter of about 9% of lagged total assets. For Non-Agency MREITs, the corresponding statistics are 14% and 6%, respectively. Agency MREITs also repurchase shares more frequently than Non-Agency MREITs (in 22% of quarters versus 12%) and repurchase more shares (0.4% of shares outstanding versus 0.2%). The mean equity-to-assets ratio over the study period is 14% for Agency MREITs, compared to 29% for Non-Agency MREITs. For Agency MREITs, the average share of repo debt to total assets is 78%, while the short-term repo debt (0-30 days) as a share of total repo debt is 47%. Non-Agency MREITs utilize repo debt to a smaller extent (16% of total assets). Agency MREITs maintain smaller cash buffers than their

¹¹ The mortgages underlying Agency MBS all have an embedded continuous prepayment option, whose value increases in the volatility of mortgage rates. The OAS measures the yield spread of the MBS after adjusting for the estimated value of this option. Ideally, one would want to observe an institution-quarter panel of security holdings and collect the related OAS to compute an institution-specific portfolio OAS. Such information is not available for MREITs, which don't file form 13-f.

Non-Agency counterparts on average (2% versus 4%). The sub-sample of institutions with available data suggests that Agency MREITs predominately hold fixed-rate Agency MBS (58% of their Agency MBS), while Non-Agency MREITs almost exclusively invest in variable-rate securities. Consistent with hedging some of the attendant interest rate risk, Agency MREITs are more intensive users of interest rate derivatives (swaps and swaptions).

[Table 1 about here.]

Table 1 also summarizes key macroeconomic variables. The average 3-month constant maturity Treasury rate is 1%. The slope of the term structure averages 2%, and the mean option-adjusted mortgage spread is 0.49%. The Federal Reserve's quarterly mean share of Agency MBS purchases to newly issued securities is 25% but ranges from 0% to 86%. The corresponding mean share of quarterly Treasury purchases is 9%, ranging from 0% to 28%.

3.2 *Time Series Trends in Agency versus Non-Agency Mortgage REIT Characteristics*

We next present aggregate time series trends for key MREIT attributes relating to their asset growth rates and capital structure choices to establish the assumption of common trends in these outcome variables across Agency and Non-Agency MREITs prior to the inception of the Federal Reserve's QE program.

Figure 4 presents quarterly data on Agency MBS holdings for both types of MREITs. In the early years of the study period, Agency MREITs slowly increased their holdings, while those at non-Agency MREITs were flat. However, after the onset of the financial crisis, Agency MREITs rapidly expanded their Agency MBS holdings. Between 2008:Q4 and 2012:Q3, these holdings rose from \$76.2 to \$337.6 billion; and Agency MREITs share of the market increased from 1.5% to 6.4%. These amounts and shares decline thereafter. By contrast, the collective holdings of Non-Agency MREITs never exceed \$50 billion, which corresponds to less than 1% of the Agency MBS market. In sum, the graphical evidence discussed here suggests that growth in total asset holdings is similar across Agency and Non-Agency MREITs prior to the Federal Reserve's QE program and diverged thereafter.

[Figure 4 about here.]

Given that REITs must distribute at least 90% of their taxable net income annually to remain exempt from federal corporate income tax, significant asset growth requires new equity issuance. Panel A of Figure 5 presents quarterly equity issuance data for Agency MREITs and Non-Agency MREITs. The figure shows low aggregate levels of equity issuance for both types of MREITs prior to QE, with quarterly issuance volumes rarely reaching \$1 billion. However, after the inception of QE we see diverging patterns in equity issuance between Agency and Non-Agency MREITs. New equity issuance by Agency MREITs is clustered between 2010 and 2012, peaking at \$6 billion in 2010:Q4, when the Federal Reserve starts QE2. The Agency MREIT equity issuance pattern documented here aligns with the asset growth pattern described above. By contrast, Non-Agency MREIT quarterly equity issuance exhibits little correlation with the Federal Reserve's stance in the Agency MBS market throughout the different QE regimes.

Panel B of Figure 5 presents the aggregate equity-to-assets ratio for Agency and Non-Agency MREITs. Agency MREITs hold approximately 8% equity in the early years of the study period, but this ratio subsequently increases and to between 12% and 15% after the start of QE. Leverage for Non-Agency MREITs is different. Their share of equity financing drifts down from 20% to 10% prior to the financial crisis, before reaching a new level of over 40% thereafter. These patterns suggest that the total leverage levels of these institutions exhibit relatively minor differences prior to the inception of the Federal Reserve's QE program but diverge markedly thereafter.

[Figure 5 about here.]

Figure 6 illustrates the differences in the debt structures of Agency and Non-Agency MREITs. Panel A shows that repurchase agreements are the dominant form of Agency MREIT debt financing (80% of total assets since the early 2000s). Non-Agency MREITs rely significantly less on repo financing, averaging less than 10% of total assets in the early years of the study period. Despite the difference in levels, the repo debt holdings of Agency and Non-Agency MREITs exhibit similar trends prior to the Federal Reserve's QE program. However, the time series patterns in repo debt holdings diverge some across the two institution types after the inception of QE. Agency MREIT repo debt holdings decline from a peak of 85% of total assets to 72% of total assets after the Federal Reserve initiates QE1 and remained below 80% of total assets until the end of the study period. By contrast, Non-Agency MREIT repo debt holdings increase from approximately 3% of total assets in 2008:Q4 and end the sample period at 10% of total assets. Panel B shows the use of short-term repo debt (< 30 days) as a share of total repo debt outstanding is consistently much higher and more volatile for Agency MREITs.

[Figure 6 about here.]

The graphical evidence provided above suggests that the time-series of institution asset growth and capital structure exhibit similar patterns across Agency and Non-Agency MREITs prior to the inception of the Federal Reserve's QE program, but diverge thereafter. This supports the assumption of common trends across the two types of institutions.

4 Event Study

We begin our empirical analysis by conducting a high-frequency event study of the equity market reactions by Agency and Non-Agency MREITs to the 14 QE announcements identified by Chodorow-Reich (2014). This analysis has two goals. The first is to illustrate that market participants expected MREITs to be materially affected by the Federal Reserve's QE and that MREIT equity prices reacted accordingly. The second goal is to document the similarities and differences in the reactions across Agency and Non-Agency MREITs, the latter of which we use as control group in our subsequent analysis of Agency MREIT growth and risk-taking in response to QE.

Following Chodorow-Reich (2014), we obtain high-frequency, tick-by-tick equity price data from TAQ to construct 5-minute average trading prices from 7 to 2 minutes before QE-related announcements to 18 to 23 minutes after. The rationale is to identify a causal relationship between monetary policy surprises and equity market movements in a manner that trades off the need for a narrow enough window such that other aggregate shocks do not influence asset prices, but one long enough so the market can plausibly digest the new information.

Table 2 presents the results for both types of MREITs. For reference, we also report the corresponding results for insurance companies, commercial banks, and the broader market from Chodorow-Reich (2014, Table 2). Our estimates show that both types of MREITs reacted to most QE announcements but with significant differences between Agency and Non-Agency MREITs. During QE1 and QE2, Agency MREITs generally reacted positively and in-line with the broader market, although the reaction was muted relative to Non-Agency MREITs, life insurers, and banks. This evidence is consistent with QE increasing legacy asset values, but with fixed-rate Agency MBS benefitting less due to negative convexity. The two forward guidance announcements during QE2 were perceived more positively for Agency MREITs than for the other financial institutions. This result is likely due to the perception that the cost of Agency MREIT short-term repo liabilities would remain low for a considerable period of time. Agency MREITs reacted more strongly than Non-Agency MREITs and other financial institutions to the announcements around QE3. The announcements in May and June of 2013, related to the so-called Taper Tantrum, were negative for Agency MREITs by unanchored expectations about their funding costs previously tied down by forward guidance. This result is reversed in the September 2013 statement, which delayed tapering.

[Table 2 about here.]

This event study serves as additional background for our main empirical analysis to follow. The results suggest that: (i) market participants clearly expected MREITs to be affected by QE; and (ii) that there are sufficient similarities, but also important differences, in the equity market reactions across Agency and Non-Agency MREITs to these announcements. This analysis shows that there is some causal impact from the Federal Reserve's QE on MREITs and that Non-Agency MREITs provide a suitable control group for our analysis of Agency MREITs.

5 QE and Agency MREIT Growth

5.1 Empirical Approach

To identify the effects of QE on Agency MREIT asset growth we compare them with Non-Agency MREITs. As illustrated by the time-series trends analysis in Section 3.2 and the event study in Section 4, Non-Agency MREITs constitute a natural control group, since they are subject to the same statutory requirements as Agency MREITs but hold a broader portfolio of mortgage-related debt. Our approach of comparing two types of institutions with differential exposure to the Agency MBS market is similar to Rodnyansky and Darmouni (2017)

and Chakraborty, Goldstein and MacKinlay (2020), who analyze differences in commercial bank lending responses to QE by comparing banks with high versus low Agency MBS portfolio holding shares.

We begin our analysis with the regression model for MREIT asset growth shown in Eq. (1):

$$\begin{aligned} \text{Asset Growth}_{i,t} = & \beta_1 \text{Agency MREIT}_i + \beta_2 \text{Fed MBS Purchase Share}_t + \beta_3 \text{Agency MREIT}_i \times \\ & \text{Fed MBS Purchase Share}_t + \beta_4 \mathbf{Macroeconomic Controls}_t + \beta_5 \mathbf{Institution Controls}_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (1)$$

where $\text{Asset Growth}_{i,t}$ denotes the quarterly growth in total assets for institution i at time t . *Agency MREIT* is an indicator that takes the value of one if institution i is an Agency MREIT (versus a Non-Agency MREIT). *Fed MBS Purchase Share* is the Federal Reserve's quarterly purchase share of Agency MBS. The regression specification in Eq. (1) includes an interaction term between the *Agency MREIT* indicator and the *Fed MBS Purchase Share* that reflects any differential response between Agency and Non-Agency MREITs to variation in *Fed MBS Purchase Share*. We anticipate that the central banks' Agency MBS purchases have a larger negative effect on investment growth opportunities for specialized Agency MREITs than for Non-Agency MREITs with a broader portfolio of mortgage-related asset holdings ($\beta_3 < 0$).

Macroeconomic Controls _{t} is a matrix containing the level and slope of the term structure, computed as the 3-month constant maturity Treasury rate and the difference between the 10-year and 3-month constant maturity rates, respectively. We also include the option-adjusted mortgage spread as a measure of the relative attractiveness of Agency MBS versus Treasury bonds. We further control for the quarterly rate of national house price growth based on the Case-Shiller Index and the credit risk premium to capture drivers of growth specific to Non-Agency MREITs. Lastly, we account for the Federal Reserve's purchase share of Treasury securities.

Institution Controls _{i,t} is a matrix of institution-specific, time-varying characteristics. We include the amount of new equity issued during the quarter as a percentage of total equity at the beginning of the quarter. This variable reflects that REITs must distribute a large fraction of their earnings as dividends, hence asset growth must largely be financed through new equity issuance. Conversely, MREITs may also contract when investment opportunities decline. Thus, we include the number of shares repurchased during the quarter as a percentage of total shares outstanding at the beginning of the quarter. We further control for MREIT size, defined as the natural logarithm of total assets, lagged by one quarter. $\varepsilon_{i,t}$ is the residual. We estimate Eq. (1) via OLS, with standard errors clustered by institution.

We further examine MREIT responses to central bank Agency MBS purchases across the QE regimes, which are each defined by different policy objectives. For example, QE1 was especially important for Agency MBS market functioning and hardening expectations about federal support for Fannie Mae and Freddie Mac (Hancock and Passmore, 2011). During the Tapering period, by contrast, the Federal Reserve was extremely transparent and consistent in its monthly asset purchase activity so as to not materially affect markets. We thus estimate an alternative version of Eq. (1) where we construct interaction terms between *Agency MREIT* and *Fed MBS Purchase*

Share where the latter is QE regime specific. We consider the following QE regimes: QE1, Maturity Extension Program (MEP), QE3, and the Tapering period. The Federal Reserve did not purchase Agency MBS during QE2 and hence we include a simple indicator to control for any unobservable policy effects during this period.

Equity issuance plays an important role in MREIT asset growth given the substantial payout requirements for these institutions, while share repurchases reflect MREITs' responses to equity investor demand for their shares. Therefore, we examine the response in equity issuance and share repurchases to variation in the Federal Reserve's posture in the Agency MBS market. Eq. (2) shows the specification of the regression model:

$$\begin{aligned} Issued\ Equity_{i,t} = & \beta_1 Agency\ MREIT_i + \beta_2 Fed\ MBS\ Purchase\ Share_t + \beta_3 Agency\ MREIT_i \times \\ Fed\ MBS\ Purchase\ Share_t & + \beta_4 \mathbf{Macroeconomic\ Controls}_t + \beta_5 \mathbf{Institution\ Controls}_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (2)$$

where $Issued\ Equity_{i,t}$ is an indicator that takes the value of one if institution i issued new equity at time t . The matrix **Macroeconomic Controls** _{t} contains the same variables as in Eq. (1). The matrix **Institution Controls** _{i,t} contains institution size (logarithm of total assets) and the ratio of market-to-book value of equity, both lagged one quarter. The remaining variables and notation are as in Eq. (1). We estimate the same variation, using QE regime-specific Federal Reserve Agency MBS purchase shares, for this regression as for Eq. (1). Eq. (2) is estimated via OLS with standard errors clustered by institution. We estimate the likelihood of quarterly share repurchases in the same framework.

5.2 Results

Table 3 presents the results of the asset growth regressions. The estimates in column (1) indicate that Agency MREITs averaged higher rates of asset growth than Non-Agency MREITs over the sample period. The same estimates also suggest that MREIT growth was negatively related to the Federal Reserve's purchase share of Agency MBS. The results reported in column (2) show that this latter effect is driven by the Agency MREITs in our sample, consistent with our first testable hypothesis. In economic terms, the estimates in column (2) suggest that a one-standard deviation increase in the Federal Reserve's purchase share was associated with a marginal reduction in Agency MREIT asset growth of 3.6 percentage points per quarter, or approximately 40% of the unconditional mean.¹² The estimates presented in column (3) suggest that Agency MREITs experienced particularly strong asset growth during QE1 and QE2. As discussed above, QE1 had the effect of driving down long-term interest rates and resulting in large capital gains for fixed-income investors that would have facilitated some growth in Agency MREITs. The further expansion of Agency MREITs during QE2 can be explained by the central bank halting its purchases of Agency MBS and no longer crowding out private investment. The results reported in column (3) also

¹² Based on estimates in Table 3, column (2). Coefficient $(-0.145) \times$ SD of Federal Reserve Purchase Share $(0.2473) =$ economic effect (-0.0359) , rounded to -3.6 percentage points. Dividing this estimated effect (-0.0359) by the unconditional mean Agency MREIT asset growth (0.0888) equals an effect equivalent to approximately -40% of the unconditional mean.

indicate that Agency MREITs experienced significantly negative asset growth during the Tapering period when the Federal Reserve’s resumed its purchases of Agency MBS.

[Table 3 about here.]

Given the important role of equity issuance for MREIT growth, we examine this directly in Table 4. The estimates in column (1) show that Agency MREITs are more likely to issue equity than Non-Agency MREITs on average; and that equity issuance is inversely related to the Federal Reserve’s Agency MBS purchases (although the latter association is statistically insignificant). The results reported in column (2) indicate that the Federal Reserve’s Agency MBS purchases have a significantly negative effect on Agency MREIT equity issuance and a significantly positive effect on Non-Agency MREIT issuance. These two coefficients with opposing signs balance each other out and thus explain the insignificant coefficient on the Federal Reserve’s Agency MBS purchase share shown in column (1). In economic terms, the estimates in column (2) imply that a one-standard deviation increase in the Federal Reserve’s Agency MBS purchase share is associated with a decline in the likelihood of equity issuance by Agency MREITs of 16 percentage points, or more than 60% of the unconditional mean.¹³

The estimates reported in column (3) of Table 4 suggest that: (i) Agency MREITs equity issuance is unaffected by the Federal Reserve’s Agency MBS purchase share during QE1; (ii) that the central bank’s absence from the Agency MBS market during QE2 is associated with a significant increase in Agency MREIT equity issuance; and (iii) that the re-entry of the Federal Reserve into the Agency MBS market during QE3 and Tapering is associated with a significant decline in Agency MREIT equity issuance. The finding of no significant difference in equity issuance across MREIT types during QE1 suggests that the growth of Agency MREITs at that time was organic and facilitated by the windfall gains associated with the announcement of that intervention. By contrast, the significant expansion and contraction of Agency MREITs during QE2 and QE3 was primarily driven by equity issuance and repurchase behavior; that is, the crowding-in and crowding-out of private capital by the Federal Reserve’s stance in the Agency MBS market. The reduction in Agency MREIT equity issuance during the Tapering Period mirrors the results we document for Agency MREIT asset growth at that time.

[Table 4 about here.]

Table 5 presents the regression results for quarterly Agency MREIT share repurchases. In column (1), we see that the two types of MREITs were, on average, equally likely to repurchase shares, and we also find no overall effect of the Federal Reserve’s Agency MBS purchase share on share repurchases. However, Agency MREIT repurchase activity increases significantly in response to the Federal Reserve’s Agency MBS purchases (column

¹³ Based on estimates in Table 4, column (2). Coefficient $(-0.636) \times$ SD of Federal Reserve Purchase Share $(0.2473) =$ economic effect (-0.1573) , rounded to -16 percentage points. Dividing this estimated effect (-0.1573) by the unconditional mean likelihood of Agency MREIT equity issuance (0.2573) equals an effect equivalent to -61% of the unconditional mean.

(2)). When considering individual QE regimes, we find that Agency MREIT share repurchases (relative to Non-Agency MREIT share repurchases) decreased significantly in response to the Federal Reserve’s Agency MBS purchase activity during QE1, QE2, and MEP, and increased during QE3 and the Tapering period. In all, the estimates reported in Table 5 indicate that the likelihood of Agency MREIT share repurchases mirrors the dynamics of their equity issuance; and this in turn, follows the time-series patterns of Agency MREIT asset growth.

[Table 5 about here.]

In sum, our results demonstrate a strong empirical relationship between the Federal Reserve’s QE program and Agency MREIT growth. These institutions grew rapidly during QE1 and QE2. QE1 was characterized by a sharp decline in long-term interest rates, generating significant capital gains for fixed income securities. During QE2, the central bank halted its purchases of Agency MBS, creating investment opportunities for Agency MREITs. For these reasons, Agency MREITs represented attractive investment opportunities during QE1 and QE2. The Federal Reserve’s purchases of Agency MBS during QE3 and the Tapering period, by contrast, were associated with a contraction in Agency MREIT size due to reduced investment opportunities. Consistent results for equity issuance and share repurchases illustrate the portfolio rebalancing by equity investors in and out of leveraged investment in Agency MBS during QE. During the later stages of QE, Agency MREITs were less attractive to investors and may thus have sought to boost expected returns by increasing the risk of their capital structures (more leverage and more short-term debt). Next, we turn to a formal investigation of this question.

6 QE and Agency MREIT Financial Risk Taking

6.1 Empirical Approach

To identify the effects of QE on Agency MREIT financial risk taking through their capital structure choices, we again employ the cross-sectional comparison to Non-Agency MREITs. We begin by exploring variation in the ratio of equity to total assets, a measure of balance sheet leverage. We then turn to two measures of their debt structure reflecting liquidity/refinancing risk: namely, the ratio of repurchase agreements to assets and the ratio of short-term repo (< 30 days) to total repo debt. Eq. (3) presents the regression specification employed:

$$Risk_{i,t} = \beta_1 Agency\ MREIT_i + \beta_2 Fed\ MBS\ Purchase\ Share_t + \beta_3 Agency\ MREIT_i \times Fed\ MBS\ Purchase\ Share_t + \beta_4 \mathbf{Macroeconomic\ Controls}_t + \beta_5 \mathbf{Institution\ Controls}_{i,t} + \varepsilon_{i,t} \quad (3)$$

where $Risk_{i,t}$ denotes the specific measure of financial risk considered. The **Macroeconomic Controls** are the same as in Eq. (1) and (2). The **Institution Controls** in Eq. (3) include institution size, defined as the natural logarithm of total assets, and institution cash holdings scaled by total assets. Cash holdings represent a liquidity buffer on the asset-side of the balance sheet that could otherwise insulate MREITs from the risk associated with their short-term liabilities. Both variables are lagged by one quarter. We also account for contemporaneous total

accumulated other comprehensive income, scaled by total assets, to control for variation in the ratio of equity to assets driven by mark-to-market gains and losses. $\varepsilon_{i,t}$ is the residual. The model in Eq. (3) is estimated via OLS with standard errors clustered by institution.

We estimate an alternative version of Eq. (3) that includes interaction terms between the period-specific Federal Reserve Agency MBS purchase shares and the Agency MREIT indicator as previously described in the context of Eq. (2). Finally, for a sub-set of MREITs with available data, we re-estimate Eq. (3) adding controls for interest rate risk exposure and hedging; namely, the lagged ratio of fixed rate to total Agency MBS and the lagged ratio of interest rate swaps and swaptions to total liabilities. Including these variables sharpens our inferences about the solvency and liquidity risks associated with MREIT capital structure choices during QE.

6.2 Results

Table 6 presents the results of the MREIT leverage regressions. The results shown in columns (1) through (3) include the baseline set of institution controls (including lagged values of institution size, cash holdings, and total accumulated other comprehensive income). The estimates reported in columns (4) through (6) refer to the results including the expanded set of institution controls (adding lagged values of the ratio of fixed- rate Agency MBS to Agency MBS and interest rate swaps and swaptions to total liabilities).

[Table 6 about here.]

The estimates in column (1) suggest that Agency MREITs hold less equity, or are more levered, than Non-Agency MREITs on average. The results reported in column (2) indicate that the Federal Reserve’s purchase activity in the Agency MBS market is associated with higher Agency MREIT leverage (lower equity holdings), although the effect is statistically insignificant. The estimates presented in column (3) suggest that Agency MREITs held lower levels of equity during QE2 and in response to the Federal Reserve’s Agency MBS purchases from the MEP onwards, although this effect is only statistically significant during QE3. In economic terms, the estimates from column (3) suggest that a one-standard deviation increase in the Federal Reserve’s purchase share of Agency MBS during QE3 was associated with a decline in the equity-to-assets ratio of Agency MREITs of over 1.7 percentage points, or approximately 12% of the unconditional mean.¹⁴ This result is consistent with “reaching for yield” behavior by Agency MREITs during a time when investment growth opportunities for these institutions were curtailed by the Federal Reserve’s purchase activity in the Agency MBS market.

When considering the expanded set of institution controls for interest rate risk and hedging presented in columns (4) through (6), the results reported are qualitatively similar. However, in contrast to those earlier findings,

¹⁴ Based on estimates in Table 6, column (3). Coefficient $(-0.151) \times \text{SD of Federal Reserve Purchase Share in QE3}$ $(0.1135) = \text{economic effect } (-0.0171)$ in both regimes, rounded to -1.7 percentage points. Dividing this estimated effect by the unconditional mean Agency MREIT equity-to-assets ratio (0.1388) equals an effect equivalent to approximately -12% .

the results suggest that the most statistically significant negative effect of the Federal Reserve’s Agency MBS purchase share on Agency MREIT equity holdings occurred during the Tapering regime.

Table 7 presents the results for MREIT use of repo debt financing. The estimates reported suggest that Agency MREITs on average use repurchase agreements more heavily (column (1)). The results presented in column (2) show that Agency MREIT repo debt holdings are inversely related to the Federal Reserve’s Agency MBS purchase share, whereas the estimates reported suggest the opposite to be the case for Non-Agency MREIT repo debt holdings. Neither of these coefficients is statistically significant. The estimates in column (3) indicate that Agency MREITs increased their use of repo debt in response to the Federal Reserve’s Agency MBS purchase share during the early QE regimes (QE1, QE2, and MEP) but lowered their use during the latter ones (QE3 and Tapering). While the coefficient estimates on the variables of interest reported in columns (1) through (3) are often numerically large, many estimates are statistically insignificant. The results for the regression specifications incorporating the expanded set of institution controls, reported in columns (4) through (6), are broadly consistent. In sum, the results in Table 7 suggest that MREIT repo debt usage was largely unaffected by the central banks’ stance in the Agency MBS market.

[Table 7 about here.]

Table 8 presents the results for MREIT exposure to a more precise measure of liquidity risk; namely, the ratio of short-term repo (0-30 days) to total repo. The results shown in column (1) indicate that Agency MREITs use significantly more short-term repo debt than their Non-Agency counterparts; and that MREIT use of short-term repo financing is positively related to the Federal Reserve’s Agency MBS purchase share. The estimates in column (2) indicate that this latter effect is driven by Non-Agency MREITs. In column (3) we see that Agency MREITs significantly reduced their reliance on short-term repo debt (relative to Non-Agency MREITs) during MEP and QE3 and this appears to have continued into the Tapering regime. The results presented in columns (4) through (6), which control for interest rate risk exposure and hedging intensity, are somewhat different and weaker economically and statistically. This suggests that Agency MREITs’ reduction in liquidity risk by extending repo maturity was generally offset by an increase in their interest rate risk exposure.

[Table 8 about here.]

In all, the results presented in Tables (6) through (8) suggest that the Federal Reserve’s purchases of Agency MBS during QE affected MREIT financial risk-taking. First, we find that Agency MREITs exhibit “reaching for yield” behavior through increased leverage during periods when their growth opportunities are curtailed by central bank asset purchases. Second, there appears to be a trade-off during these times between reducing liquidity risk by extending repo maturity and increased interest rate risk exposure.

7 Concluding Remarks

The prolonged use of unconventional monetary policy since the financial crisis resulted in concerns about the potential for such accommodation to undermine financial stability. Recent research presents evidence consistent with “reaching for yield” by non-bank financial institutions during QE via increased *credit* risk taking. We test the complementary hypothesis that QE may also influence *financial* risk taking. We study Agency Mortgage REITs, which are shadow banks that hold long-term Agency MBS and financed using repo debt provided by broker-dealers. This simple intermediation structure allows us to shut off any credit risk taking response to QE and isolate any potential response in terms of capital structure choices. To identify the effects of QE on institution-level outcomes, we employ a cross-sectional comparison between Agency MREITs and all other MREITs, which serve as a control group of institutions holding a broader portfolio of mortgage-related assets.

We first conduct a high-frequency event study of equity market reactions by Agency and Non-Agency MREITs to QE-related central bank communications. The results suggest a causal impact from the Federal Reserve’s QE announcements on MREIT valuations. We then estimate panel regressions showing that Agency MREIT asset growth responded negatively to the Federal Reserve’s purchase share of newly issued Agency MBS during QE. This dynamic is confirmed by additional analysis studying Agency MREIT equity issuance and share repurchase behavior. These results demonstrate that the Federal Reserve’s Agency MBS purchases directly crowd out private-sector investment and induce portfolio rebalancing by equity investors in Agency MREITs. We further document that the Federal Reserve’s purchase activity in the Agency MBS market was associated with a significant increase in Agency MREIT leverage during the late stages of QE – consistent with “reaching for yield” through riskier capital structure choices. We also find some evidence of a trade-off during these times between reducing liquidity risk by extending repo maturity and increased interest rate risk exposure. Overall, our findings present novel evidence that unconventional monetary policy significantly affects institution *financial* risk taking.

Bibliography

- Acharya, Viral and Hassan Naqvi, 2019. "On Reaching for Yield and the Coexistence of Bubbles and Negative Bubbles." *Journal of Financial Intermediation*, 38: 1-10. <https://doi.org/10.1016/j.jfi.2018.08.001>
- Adrian, Tobias and Hyun Shin, 2010. "Financial Intermediaries and the Price of Risk." Federal Reserve Bank of New York Staff Reports #398 (May).
- Baker, Malcolm and Jeffrey Wurgler. 2000. "The Equity Share in New Issues and Aggregate Stock Returns." *Journal of Finance*, 55(5): 2219-57. <https://doi.org/10.1111/0022-1082.00285>
- Bauer, Michael and Glenn Rudebusch, 2014. "The Signaling Channel for Federal Reserve Bond Purchases." *International Journal of Central Banking*, x: 233-289.
- Bernanke, Ben, 2010. "The Economic Outlook and Monetary Policy." Remarks at the *Federal Reserve Bank of Kansas City Economic Symposium* (August 27).
- Bernanke, Ben, 2013. "Testimony before the Joint Economic Committee, U.S. Congress." (May 22).
- Bonfim, Diana and Carla Soares, 2018. "The Risk Taking Channel of Monetary Policy: Exploring All Avenues." *Journal of Money, Credit, and Banking*, 50(7): 1507-1541. <https://doi.org/10.1111/jmcb.12500>
- Borio, Claudio and Haibin Zhu, 2012. "Capital Regulation, Risk Taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" *Journal of Financial Stability*, 8: 236-251. <https://doi.org/10.1016/j.jfs.2011.12.003>
- Chakraborty, Indraneel, Itay Goldstein, and Andrew MacKinlay, 2020. "Monetary Stimulus and Bank Lending." *Journal of Financial Economics*, 136(1): 189-218. <https://doi.org/10.1016/j.jfineco.2019.09.007>
- Choi, Jaewon and Mathias Kronlund, 2018. "Reaching for Yield by Corporate Bond Mutual Funds." *Review of Financial Studies*, 31(5): 1930-1965. <https://doi.org/10.1093/rfs/hhx132>
- Chodorow-Reich, Gabriel, 2014. "The Effects of Unconventional Monetary Policy on Financial Institutions." *Brookings Papers on Economic Activity* (Spring): 155-204.
- Clouse, James, Dale Henderson, Athanasios Orphanides, David H. Small and P.A. Tinsley, 2003. "Monetary Policy When the Nominal Short-Term Interest Rate is Zero." *B.E. Journal of Macroeconomics*, (1): 1-65.
- D'Amico, Stefania and Thomas King, 2013. "Flow and Stock Effects of Large-Scale Treasury Purchases: Evidence on the Importance of Local Supply." *Journal of Financial Economics*, 108(2): 425-48. <https://doi.org/10.1016/j.jfineco.2012.11.007>
- Delis, Manthos, Iftexhar Hasan, and Nikolas Mylonidis, 2017. "The Risk Taking Channel of Monetary Policy in the U.S.: Evidence from Corporate Loan Data." *Journal of Money, Credit, and Banking*, 49(1): 187-213. <https://doi.org/10.1111/jmcb.12372>
- Dell'Ariccia, Giovanni, Luc Leaven, and Gustavo Suarez, 2016. "Bank Leverage and Monetary Policy's Risk Taking Channel: Evidence from the United States." *Journal of Finance*, 72(2): 613-654. <https://doi.org/10.1111/jofi.12467>
- DiMaggio, Marco and Marcin Kacperczyk, 2016. "The Unintended Consequences of the Zero Lower Bound Policy." *Journal of Financial Economics*, 123(1): 59-80. <https://doi.org/10.1016/j.jfineco.2016.09.006>

- Eggertsson, Gauti B. and Michael Woodford, 2003. "The Zero Bound on Interest Rates and Optimal Monetary Policy." *Brookings Papers on Economic Activity*, 2003(1): 139-211.
- Eisenbeis, Robert A., W. Scott Frame and Larry D. Wall, 2007. "An Analysis of the Systemic Risks Posed by Fannie Mae and Freddie Mac and An Evaluation of the Policy Options for Reducing Those Risks." *Journal of Financial Services Research*, 31(2-3): 75-99. [tps://doi.org/10.1007/s10693-006-0002-z](https://doi.org/10.1007/s10693-006-0002-z)
- Feroli, Michael, Anil Kashyap, Kermit Schoenholtz, and Hyun Shin, 2014. "Market Tantrums and Monetary Policy," Chicago Booth Working paper 14-09.
- Frame, W. Scott, Andreas Fuster, Joseph Tracy, and James Vickery, 2015. "The Rescue of Fannie Mae and Freddie Mac." *Journal of Economic Perspectives*, 29(2): 25-52.
- Gabaix, Xavier, Arvind Krishnamurthy, and Olivier Vigneron, 2007. "Limits of Arbitrage: Theory and Evidence from the Mortgage-Backed Securities Market." *Journal of Finance*, 62(2): 557-596. <https://doi.org/10.1111/j.1540-6261.2007.01217.x>
- Gagnon, Joseph, Matthew Raskin, Julie Remache, and Brian Sack, 2010. "Large Scale Asset Purchases by the Federal Reserve: Did They Work?" Federal Reserve Bank of New York Staff Report 441 (March).
- Hamilton, James and Jing Cynthia Wu, 2012. "The Effectiveness of Alternative Monetary Policy Tools in a Zero Lower Bound Environment." *Journal of Money, Credit, and Banking*, 44(1): 3-46. <https://doi.org/10.1111/j.1538-4616.2011.00477.x>
- Hancock, Diana and Wayne Passmore, 2011. "Did the Federal Reserve's MBS Purchase Program Lower Mortgage Rates?" *Journal of Monetary Economics*, 58: 498-514. <https://doi.org/10.1016/j.jmoneco.2011.05.002>
- Ioannidou, Vasso, Steven Ongena, and Jose Luis Peydro, 2015. "Monetary Policy, Risk Taking, and Pricing: Evidence from a Quasi-Natural Experiment," *Review of Finance*, 19(1): 95-144. <https://doi.org/10.1093/rof/rfu035>
- Jimenez, Gabriel, Steven Ongena, Jose Luis Peydro, and Jesus Saurina, 2014. "Hazardous Times for Monetary Policy: What do 23 Million Loans Say about the Impact of Monetary Policy on Credit Risk Taking?" *Econometrica*, 82: 463-505. <https://doi.org/10.3982/ecta10104>
- Kandrac, John, and Bernd Schulusche, 2017. "Quantitative Easing and Bank Risk Taking: Evidence from Lending." FEDS Working Paper No. 2017-125. <https://doi.org/10.17016/feds.2017.125>
- Krishnamurthy, Arvind and Annette Vissing-Jorgensen, 2011. "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy." *Brookings Papers on Economic Activity*, 215-265. <https://doi.org/10.1353/eca.2011.0019>
- Morris, Stephen and Hyun Shin, 2016. "Risk Premium Shifts and Monetary Policy: A Coordination Approach" in *Monetary Policy through Asset Markets: Lessons from Unconventional Measures and Implications for an Integrated World*, edited by Michael Woodford, Diego Saravia and Elias Albagli. Banco Central de Chile.
- Neely, Christopher, 2012. "Unconventional Monetary Policy Had Large International Effects." *Journal of Banking and Finance*, 52: 101-111. <https://doi.org/10.1016/j.jbankfin.2014.11.019>
- Paligorova, Teodora and Joao Santos, 2017. "Monetary Policy and Bank Risk Taking: Evidence from the Corporate Loan Market" *Journal of Financial Intermediation*, 30: 35-49. <https://doi.org/10.1016/j.jfi.2016.11.003>
- Passmore Wayne, 2005. "The GSE Implicit Subsidy and the Value of Government Ambiguity." *Real Estate Economics*, 33(3): 465-486. <https://doi.org/10.1111/j.1540-6229.2005.00126.x>

Rajan, Raghuram, 2005. “Has Financial Development Made the World Riskier?” NBER Working Paper #11728. <https://doi.org/10.3386/w11728>

Rodnyansky, Alexander, and Olivier M. Darmouni, 2017. “The Effects of Quantitative Easing on Bank Lending Behavior.” *Review of Financial Studies*, 30(11): 3858–3887. <https://doi.org/10.1093/rfs/hhx063>

U.S. Financial Stability Oversight Council, 2013. Annual Report.

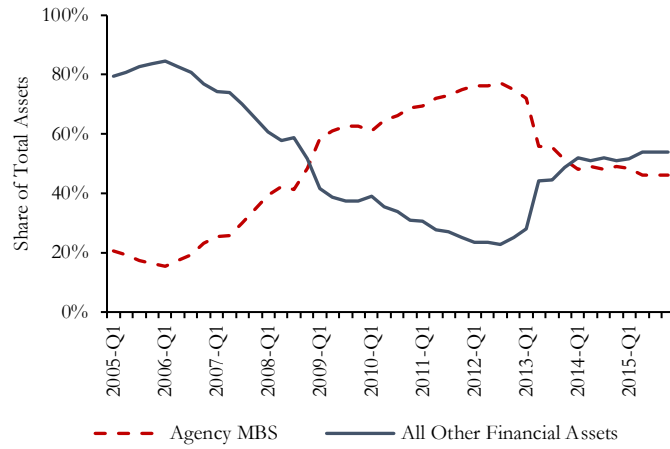
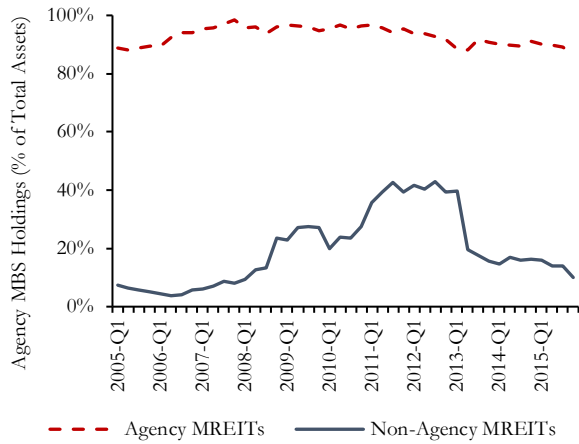
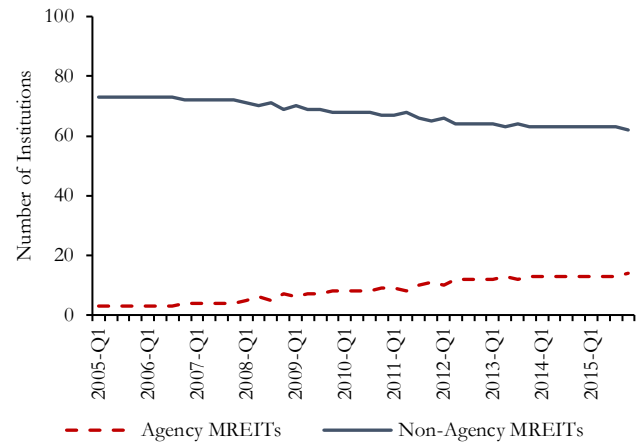


Figure 1: Mortgage REIT Investment Shares. The figure shows MREIT investment in Agency MBS and All Other Financial Assets as a share of total assets between 2005:Q1 and 2015:Q4. Data are from the Federal Reserve Flow of Funds Reports.

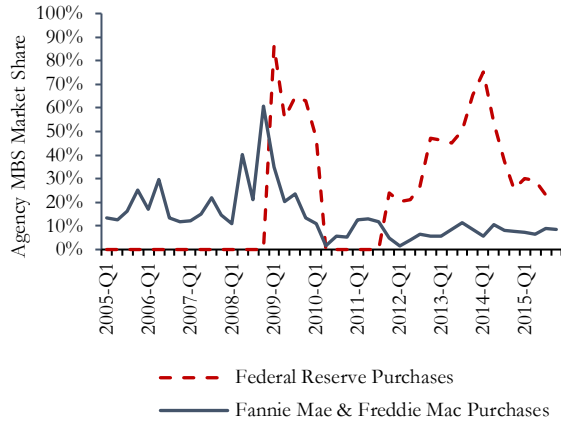


(A) Holdings of Agency MBS

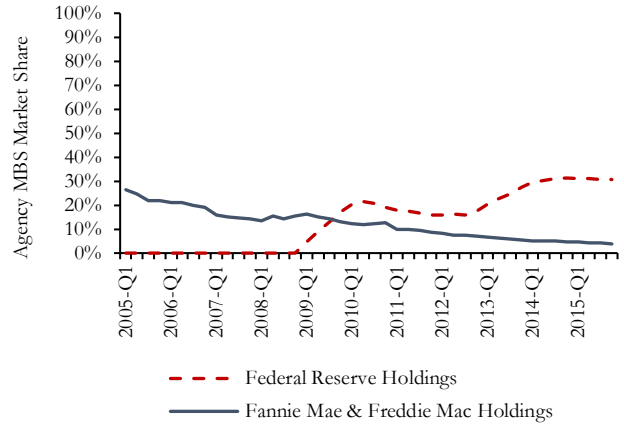


(B) Number of Mortgage REITs

Figure 2: Mortgage REIT Agency MBS Holdings and Number of Institutions. The figure shows Agency MBS Holdings as a share of Total Assets for Agency and Non-Agency MREITs (Panel A), alongside the number of active Agency and Non-Agency MREITs (Panel B). Data come from S&P Global and cover between 2005:Q1 and 2015:Q4.



(A) Purchase Share (% of Total Agency MBS Issuance)



(B) Holdings Share (% of Total Agency MBS Outstanding)

Figure 3: Federal Reserve and GSE Agency MBS Market Shares. The figure shows the shares of Agency MBS purchases (holdings) in Panel A (Panel B) for the Federal Reserve System and Fannie Mae/Freddie Mac between 2005:Q1 and 2015:Q4. Data are from the Federal Reserve Bank of New York.

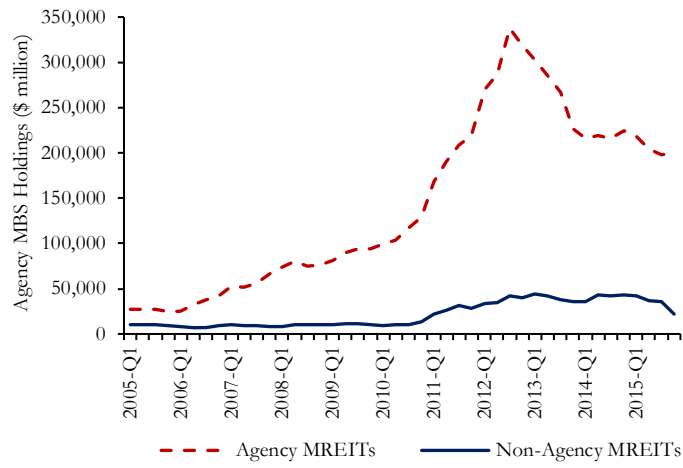
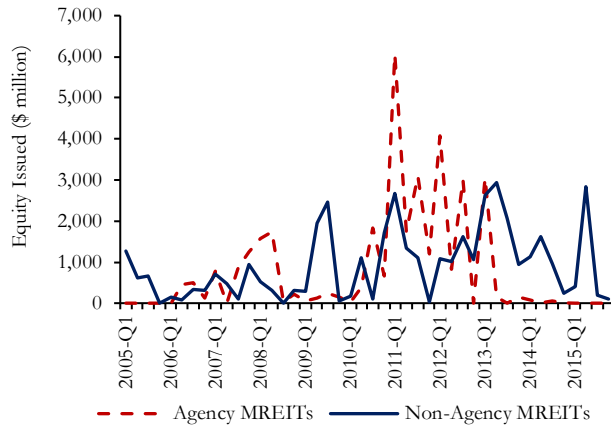
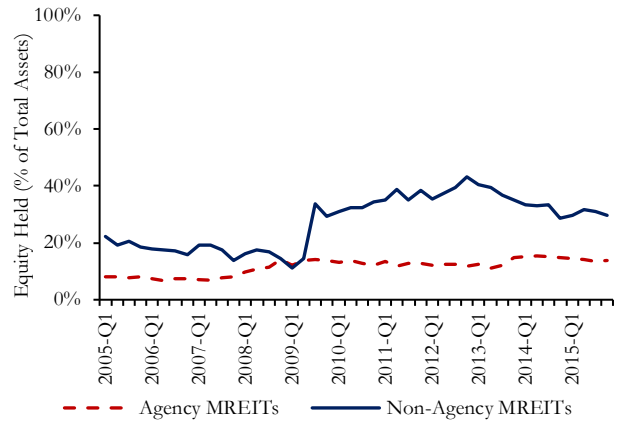


Figure 4: Mortgage REIT Agency MBS Holdings. The figure shows total Agency MBS assets held by Agency MREITs and Non-Agency MREITs (\$ million) between 2005:Q1 and 2015:Q4. Data are from S&P Global.

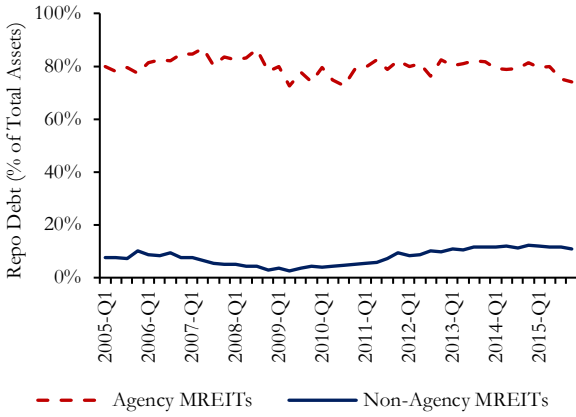


(A) Amount of Equity Issued

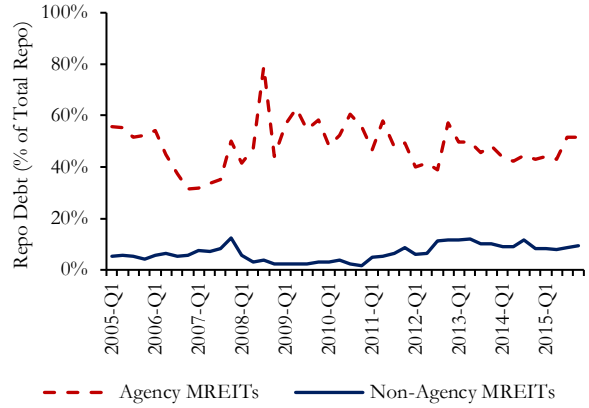


(B) Amount of Equity Held

Figure 5: Mortgage REIT Equity Issuance and Holdings. The figure shows Agency MREIT and Non-Agency MREIT total equity issuance (in \$ million) in Panel A, and the total amount of equity held (scaled by total assets) in Panel B. Data are from S&P Global and cover between 2005:Q1 and 2015:Q4.



(A) Repo Debt Holdings



(B) Short-Term Repo Debt Holdings

Figure 6: Mortgage REIT Repo Debt Holdings. The figure shows total financing through repo debt, scaled by total assets (Panel A) and total financing through short-term repo debt scaled by total repo debt (Panel B) for Agency and Non-Agency MREITs. Data come from S&P Global and cover 2005:Q1 to 2015:Q4.

Table 1: Descriptive Statistics

The table presents descriptive statistics for the variables of interest over the study period 2005—2015. All variables are defined in Section 3. Difference denotes the difference in means between Agency MREITs and Non-Agency MREITs. Significance from a two-sided t-test between the mean values observed for Agency and Non-Agency MREITs is indicated as follows: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Panel A: Agency MREITs	N	Mean	SD	P25	Median	P75	Min	Max	Difference
Total Assets	447	18.0000	25.5000	4.4600	8.6300	17.5000	0.1920	142.0000	13.6700***
Growth in Assets	447	0.0888	0.2582	-0.0263	0.0149	0.0972	-0.3471	1.6464	0.0254
Agency MBS/Assets	447	0.8364	0.1547	0.7290	0.9091	0.9608	0.4135	0.9960	0.7760***
Issued Equity	447	0.2573	0.4376	0.0000	0.0000	1.0000	0.0000	1.0000	0.1222***
Amount Issued	447	0.0864	0.2356	0.0000	0.0000	0.0032	0.0000	1.6105	0.0262
Repurchased Shares	447	0.2215	0.4157	0.0000	0.0000	0.0000	0.0000	1.0000	0.1062***
Number Repurchased	447	0.0039	0.0127	0.0000	0.0000	0.0000	0.0000	0.1275	0.0021***
Market-to-Book Value	447	0.8897	0.1636	0.774	0.8857	0.9966	0.3208	1.4137	-0.0515**
Equity/Assets	447	0.1388	0.0509	0.1053	0.1247	0.1561	0.0617	0.3770	-0.1552***
AOCI/Assets	447	0.0055	0.0151	-0.0004	0.0009	0.0125	-0.0348	0.0673	0.0056***
Cash/Assets	447	0.0208	0.0189	0.0073	0.0191	0.0297	0.0000	0.2201	-0.0185***
Repo Debt/Assets	447	0.7831	0.0965	0.7387	0.8077	0.8545	0.3152	0.9147	0.6211***
Repo Debt (0-30)/Total Repo	447	0.4661	0.3006	0.2636	0.4735	0.7232	0.0000	1.0000	0.2976***
Fixed-Rate MBS/Agency MBS	319	0.5762	0.3872	0.0030	0.7358	0.9095	0.0000	1.0000	0.4855***
Swaps & Swaptions/Liabilities	400	0.4792	0.2492	0.3567	0.4629	0.6030	0.0000	1.2060	0.3414***
Panel B: Non-Agency MREITs	N	Mean	SD	P25	Median	P75	Min	Max	
Total Assets	555	4.3300	7.1700	0.6910	1.9700	5.3000	0.0050	57.5000	
Growth in Assets	555	0.0634	0.2507	-0.0286	0.0103	0.0916	-0.5563	1.9771	
Agency MBS/Assets	555	0.0604	0.1378	0.0000	0.0000	0.0386	0.0000	0.8453	
Issued Equity	555	0.1351	0.3422	0.0000	0.0000	0.0000	0.0000	1.0000	
Amount Issued	555	0.0602	0.3175	0.0000	0.0000	0.0000	0.0000	4.0618	
Repurchased Shares	555	0.1153	0.3197	0.0000	0.0000	0.0000	0.0000	1.0000	
Number Repurchased	555	0.0018	0.0096	0.0000	0.0000	0.0000	0.0000	0.1452	
Market-to-Book Value	555	0.9412	0.4041	0.7361	0.9569	1.1644	-0.3463	2.0508	
Equity/Assets	555	0.2940	0.2523	0.0978	0.2197	0.4191	-0.1007	0.9945	
AOCI/Assets	553	-0.0001	0.0328	-0.0049	0.0000	0.0023	-0.2311	0.2086	
Cash/Assets	555	0.0393	0.0927	0.0066	0.0160	0.0384	0.0002	1.0000	
Repo Debt/Assets	555	0.1620	0.2079	0.0000	0.0625	0.2664	0.0000	0.8864	
Repo Debt (0-30)/Total Repo	555	0.1685	0.3279	0.0000	0.0000	0.0998	0.0000	1.0000	
Fixed-Rate MBS/Agency MBS	166	0.0907	0.2294	0.0000	0.0000	0.0000	0.0000	1.0000	
Swaps & Swaptions/Liabilities	518	0.1378	0.2145	0.0000	0.0519	0.1938	0.0000	1.7574	
Panel C: Macroeconomic Variables	N	Mean	SD	P25	Median	P75	Min	Max	
3-Month CMT	44	1.0250	1.7187	0.0300	0.0900	1.1500	0.0100	5.0800	
CMT Term Structure	44	2.0040	1.0159	1.6100	2.1800	2.6700	-0.5200	3.5800	
Option-Adjusted Spread	44	0.4866	0.2911	0.2700	0.3800	0.5800	0.1100	1.4500	
Credit Spread	44	2.7349	0.7816	2.2600	2.7500	3.0800	1.5900	5.8200	
Case-Shiller House Price Index	44	0.0049	0.0301	-0.0078	0.0066	0.0272	-0.0696	0.0742	
Fed MBS Purchase Share	44	0.2470	0.2473	0.0000	0.2383	0.4641	0.0000	0.8622	
Fed Treasury Purchase Share	44	0.0993	0.0850	0.0364	0.0671	0.1912	0.0000	0.2815	
Fed MBS Holdings Share	44	0.1646	0.1184	0.0000	0.1749	0.2934	0.0000	0.3129	
Fed Treasury Holdings Share	44	0.0822	0.0553	0.0000	0.0978	0.1327	0.0000	0.1392	

Table 2: Event Study

The table presents the estimation results from the event study analysis. Difference is the difference in the estimates for Agency MREITs versus Non-Agency MREITs. Significance is indicated as follows: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, respectively, based on the larger of the conventional or robust standard error from a regression of the change in the asset price on a constant on the date indicated. Periods are defined as follows: Initial QE: 12/16/2008 and 03/18/2009; Taper: 05/22/2013 and 06/19/2013; Sample end: 07/10/2013 and 09/18/2013. Totals may differ due to rounding or sample composition.

Regime	Date	Treasury	Life Insurers	Banks	Market	Agency MREITs	Non-Agency MREITs	Difference
QE1	12/01/2008	-9.2	-0.4	-0.6***	-0.5***	0.3	-0.6	0.9*
QE1	12/16/2008	-16.8	3.6***	2.2***	1.3***	1.2***	2.2***	-1.0**
QE1	01/28/2009	3.1	-1.2***	-0.3	-0.3***	0.0	-0.7***	0.7***
QE1	03/18/2009	-22.8	4.0***	2.5***	1.5***	1.0**	1.7**	-0.7
QE1	09/23/2009	-8.9	0.6***	0.6***	0.6***	0.4***	0.6***	-0.2*
QE2	08/10/2010	-5.8	0.8***	0.9***	0.7***	0.4***	0.5***	-0.1
QE2	09/21/2010	-1.8	0.6***	0.7***	0.5***	0.1**	0.1	0.0
FG	08/09/2011	-14.4	-2.0***	-1.7***	-1.4***	1.7**	-0.4	2.1***
FG	01/25/2012	-6.3	-0.6***	0.0	0.3***	0.6***	0.3***	0.3*
QE3	09/13/2012	6.4	1.3***	1.0***	0.5***	0.3***	0.3***	0.0
QE3	05/22/2013	6.6	-0.4***	-0.5***	-0.5***	-1.2***	-0.5***	-0.7**
QE3	06/19/2013	7.8	0.1	0.2***	-0.2***	-1.3***	-0.6***	-0.7**
QE3	07/10/2013	-7.3	0.3	0.0	0.3***	0.5	0.5	0.0
QE3	09/18/2013	-14.0	0.4	0.9***	1.0***	2.8***	1.8***	1.0***
Initial QE		-39.7	7.6***	4.5***	2.9***	2.2***	4.0***	-1.9*
Taper		14.4	-0.3***	-0.4***	-0.6***	-2.5***	-1.1***	-1.3**
Sample end		-21.4	0.4	0.9***	1.2	3.2***	1.9***	1.2***

Table 3: Quarterly Asset Growth

The table presents the panel regression results for Agency versus Non-Agency MREIT asset growth (quarterly percentage change in the book value of assets) as a function of macroeconomic controls (level and slope of the term structure, option-adjusted mortgage spread, credit spread, growth in the Case-Shiller House Price index, and the Federal Reserve purchase share of Treasury securities), institution controls (equity issuance, share repurchases, and lagged institution size), as well as the Federal Reserve purchase share of Agency MBS. The study period is 2005—2015. All estimates are produced using OLS. Robust standard errors (clustered by institution) are reported in parentheses. Significance is indicated as follows: *** p<0.01; ** p<0.05; * p<0.1.

	Asset Growth		
	(1)	(2)	(3)
Agency MREIT	0.038** (0.018)	0.076*** (0.027)	0.033 (0.021)
Fed MBS Purchase Share	-0.080** (0.035)	-0.013 (0.045)	
Agency MREIT*Fed MBS Purchase Share		-0.145** (0.063)	
Fed MBS Purchase Share QE1			-0.066 (0.044)
QE2			-0.002 (0.041)
Fed MBS Purchase Share MEP			0.386 (0.465)
Fed MBS Purchase Share QE3			0.052 (0.079)
Fed MBS Purchase Share Taper			0.113* (0.061)
Agency MREIT*Fed MBS Purchase Share QE1			0.126** (0.060)
Agency MREIT*QE2			0.207*** (0.048)
Agency MREIT*Fed MBS Purchase Share MEP			0.119 (0.497)
Agency MREIT*Fed MBS Purchase Share QE3			-0.121 (0.074)
Agency MREIT*Fed MBS Purchase Share Taper			-0.159** (0.068)
Macroeconomic Controls	Yes	Yes	Yes
Institution Controls	Yes	Yes	Yes
Constant	Yes	Yes	Yes
Observations	1,002	1,002	1,002
R-squared	0.443	0.448	0.467
Number of Firm Clusters	50	50	50

Table 4: Quarterly Equity Issuance

The table presents panel regression results for Agency versus Non-Agency MREIT quarterly equity issuance (measured as an indicator taking the value of one if the institution issued equity) as a function of macroeconomic controls (level and slope of the term structure, option-adjusted mortgage spread, credit spread, growth in the Case-Shiller House Price index, and the Federal Reserve purchase share of Treasury securities), institution controls (lagged market-to-book ratio and lagged institution size), and the Federal Reserve purchase share of Agency MBS. The study period is 2005—2015. All estimates are produced using OLS. Robust standard errors (clustered by institution) are reported in parentheses. Significance is indicated as follows: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

	Issued Equity		
	(1)	(2)	(3)
Agency MREIT	0.111**	0.280***	0.191***
	(0.053)	(0.058)	(0.048)
Fed MBS Purchase Share	-0.088	0.212**	
	(0.102)	(0.087)	
Agency MREIT*Fed MBS Purchase Share		-0.636***	
		(0.138)	
Fed MBS Purchase Share QE1			0.046
			(0.074)
QE2			-0.053
			(0.093)
Fed MBS Purchase Share MEP			(0.061)
			(0.542)
Fed MBS Purchase Share QE3			0.207
			(0.151)
Fed MBS Purchase Share Taper			0.382**
			(0.157)
Agency MREIT*Fed MBS Purchase Share QE1			0.084
			(0.239)
Agency MREIT*QE2			0.239**
			(0.105)
Agency MREIT*Fed MBS Purchase Share MEP			-0.510
			(0.639)
Agency MREIT*Fed MBS Purchase Share QE3			-0.600***
			(0.168)
Agency MREIT*Fed MBS Purchase Share Taper			-0.719***
			(0.193)
Macroeconomic Controls	Yes	Yes	Yes
Institution Controls	Yes	Yes	Yes
Constant	Yes	Yes	Yes
Observations	1,002	1,002	1,002
R-squared	0.128	0.164	0.178
Number of firm clusters	50	50	50

Table 5: Quarterly Share Repurchases

The table presents panel regression results for Agency versus Non-Agency MREIT quarterly share repurchases (measured as an indicator taking the value of one if the institution repurchased shares) as a function of macroeconomic controls (level and slope of the term structure, option-adjusted mortgage spread, credit spread, growth in the Case-Shiller House Price index, and the Federal Reserve purchase share of Treasury securities), institution controls (lagged market-to-book ratio and lagged institution size), and the Federal Reserve purchase share of Agency MBS. The study period is 2005—2015. All estimates are produced using OLS. Robust standard errors (clustered by institution) are reported in parentheses. Significance is indicated as follows: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

	Repurchased Shares		
	(1)	(2)	(3)
Agency MREIT	0.063 (0.054)	-0.048 (0.048)	0.053 (0.050)
Fed MBS Purchase Share	0.087 (0.075)	-0.113 (0.118)	
Agency MREIT*Fed MBS Purchase Share		0.422*** (0.126)	
Fed MBS Purchase Share QE1			0.150 (0.162)
QE2			0.240*** (0.066)
Fed MBS Purchase Share MEP			1.136** (0.457)
Fed MBS Purchase Share QE3			-0.101 (0.062)
Fed MBS Purchase Share Taper			-0.247*** (0.077)
Agency MREIT*Fed MBS Purchase Share QE1			-0.335* (0.175)
Agency MREIT*QE2			-0.163** (0.070)
Agency MREIT*Fed MBS Purchase Share MEP			-1.341*** (0.499)
Agency MREIT*Fed MBS Purchase Share QE3			0.568*** (0.148)
Agency MREIT*Fed MBS Purchase Share Taper			0.342** (0.135)
Macroeconomic Controls	Yes	Yes	Yes
Institution Controls	Yes	Yes	Yes
Constant	Yes	Yes	Yes
Observations	1,002	1,002	1,002
R-squared	0.082	0.100	0.141
Number of firm clusters	50	50	50

Table 6: Quarterly Equity to Total Assets Ratio

The table presents the panel regression results for Agency versus Non-Agency MREIT equity to total assets ratios as a function of macroeconomic controls (level and slope of the term structure, option-adjusted mortgage spread, credit spread, growth in the Case-Shiller House Price index, and the Federal Reserve purchase share of Treasury securities), institution controls, and the Federal Reserve purchase share of Agency MBS. The results in columns (1) through (3) refer to the standard set of institution controls (lagged institution size, lagged cash holdings, and total accumulated other comprehensive income scaled by total assets). The results in columns (4) through (6) refer to the expanded set of institution controls (standard institution controls plus lagged share of fixed-rate MBS holdings and lagged holdings of swaps and swaptions scaled by total repo debt holdings). The study period is 2005—2015. All estimates are produced using OLS. Robust standard errors (clustered by institution) are reported in parentheses. Significance is indicated as follows: *** p<0.01; ** p<0.05; * p<0.1.

	Standard Institution Controls			Expanded Institution Controls		
	(1)	(2)	(3)	(4)	(5)	(6)
Agency MREIT	-0.089**	-0.074*	-0.062**	-0.036	-0.007	-0.008
	(0.038)	(0.039)	(0.029)	(0.041)	(0.031)	(0.029)
Fed MBS Purchase Share	0.007	0.033		0.040	0.135*	
	(0.023)	(0.038)		(0.028)	(0.072)	
Agency MREIT*Fed MBS Purchase Share		-0.056			-0.133*	
		(0.048)			(0.071)	
Fed MBS Purchase Share QE1			-0.060			0.182
			(0.061)			(0.194)
QE2			0.062			0.034
			(0.044)			(0.050)
Fed MBS Purchase Share MEP			0.203			0.341
			(0.254)			(0.275)
Fed MBS Purchase Share QE3			0.148**			0.120
			(0.061)			(0.074)
Fed MBS Purchase Share Taper			0.110*			0.095*
			(0.059)			(0.053)
Agency MREIT*Fed MBS Purchase Share QE1			0.035			-0.204
			(0.075)			(0.205)
Agency MREIT*QE2			-0.072			-0.049
			(0.057)			(0.063)
Agency MREIT*Fed MBS Purchase Share MEP			-0.333			-0.337
			(0.336)			(0.308)
Agency MREIT*Fed MBS Purchase Share QE3			-0.151*			-0.124
			(0.077)			(0.079)
Agency MREIT*Fed MBS Purchase Share Taper			-0.107			-0.097*
			(0.067)			(0.049)
Macroeconomic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Institution Controls	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,000	1,000	1,000	474	474	474
R-squared	0.473	0.474	0.487	0.453	0.477	0.492
Number of Firm Clusters	50	50	50	25	25	25

Table 7: Quarterly Repo to Total Assets Ratio

The table presents the panel regression results for Agency versus Non-Agency MREIT repurchase agreements to total assets ratios as a function of macroeconomic controls (level and slope of the term structure, option-adjusted mortgage spread, credit spread, growth in the Case-Shiller House Price index, and the Federal Reserve purchase share of Treasury securities), institution controls, as well as Federal Reserve purchase share of Agency MBS. The results in columns (1) through (3) refer to the standard set of institution controls (lagged institution size, lagged cash holdings, and total accumulated other comprehensive income scaled by total assets). The results in columns (4) through (6) refer to the expanded set of institution controls (standard institution controls plus lagged share of fixed-rate MBS holdings and lagged holdings of swaps and swaptions scaled by total repo debt holdings). The study period is 2005—2015. All estimates are produced using OLS. Robust standard errors (clustered by institution) are reported in parentheses. Significance is indicated as follows: *** p<0.01; ** p<0.05; * p<0.1.

	Standard Institution Controls			Expanded Institution Controls		
	(1)	(2)	(3)	(4)	(5)	(6)
Agency MREIT	0.596*** (0.045)	0.615*** (0.045)	0.595*** (0.044)	0.491*** (0.056)	0.530*** (0.058)	0.517*** (0.056)
Fed MBS Purchase Share	0.046 (0.030)	0.080 (0.053)		0.090* (0.043)	0.218 (0.152)	
Agency MREIT*Fed MBS Purchase Share		-0.071 (0.073)			-0.180 (0.170)	
Fed MBS Purchase Share QE1			-0.054 (0.054)			0.035 (0.083)
QE2			0.001 (0.041)			0.045 (0.061)
Fed MBS Purchase Share MEP			-0.028 (0.146)			0.017 (0.387)
Fed MBS Purchase Share QE3			0.116 (0.093)			0.225 (0.211)
Fed MBS Purchase Share Taper			0.139* (0.080)			0.235* (0.125)
Agency MREIT*Fed MBS Purchase Share QE1			0.090 (0.059)			0.017 (0.077)
Agency MREIT*QE2			0.038 (0.040)			-0.060 (0.078)
Agency MREIT*Fed MBS Purchase Share MEP			0.311 (0.207)			0.085 (0.483)
Agency MREIT*Fed MBS Purchase Share QE3			-0.048 (0.110)			-0.175 (0.246)
Agency MREIT*Fed MBS Purchase Share Taper			-0.121 (0.101)			-0.218 (0.159)
Macroeconomic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Institution Controls	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,000	1,000	1,000	474	474	474
R-squared	0.802	0.802	0.805	0.734	0.740	0.741
Number of firm clusters	50	50	50	25	25	25

Table 8: Quarterly Repo (0-30 days) to Total Repo Ratio

The table presents the panel regression results for Agency versus Non-Agency MREIT use of short-term repo debt (repo (0-30) to total repo debt) as a function of macroeconomic controls (level and slope of the term structure, option-adjusted mortgage spread, credit spread, growth in the Case-Shiller House Price index, and the Federal Reserve purchase share of Treasury securities), institution controls, as well as Federal Reserve purchase share of Agency MBS. The results in columns (1) through (3) refer to the standard set of institution controls (lagged institution size, lagged cash holdings, and total accumulated other comprehensive income scaled by total assets). The results in columns (4) through (6) refer to the expanded set of institution controls (standard institution controls plus lagged share of fixed-rate MBS holdings and lagged holdings of swaps and swaptions scaled by total repo debt holdings). The study period is 2005—2015. All estimates are produced using OLS. Robust standard errors (clustered by institution) are reported in parentheses. Significance is indicated as follows: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

	Standard Institution Controls			Expanded Institution Controls		
	(1)	(2)	(3)	(4)	(5)	(6)
Agency MREIT	0.230*** (0.086)	0.268*** (0.085)	0.292*** (0.083)	0.491*** (0.056)	0.530*** (0.058)	0.517*** (0.056)
Fed MBS Purchase Share	0.099** (0.049)	0.168* (0.093)		0.090* (0.043)	0.218 (0.152)	
Agency MREIT*Fed MBS Purchase Share		-0.146 (0.152)			-0.180 (0.170)	
Fed MBS Purchase Share QE1			-0.042 (0.120)			0.035 (0.083)
QE2			-0.016 (0.068)			0.045 (0.061)
Fed MBS Purchase Share MEP			0.584 (0.439)			0.017 (0.387)
Fed MBS Purchase Share QE3			0.370** (0.178)			0.225 (0.211)
Fed MBS Purchase Share Taper			0.167 (0.117)			0.235* (0.125)
Agency MREIT*Fed MBS Purchase Share QE1			0.195 (0.145)			0.017 (0.077)
Agency MREIT*QE2			(0.027)			-0.060 (0.078)
Agency MREIT*Fed MBS Purchase Share MEP			-1.105* (0.630)			0.085 (0.483)
Agency MREIT*Fed MBS Purchase Share QE3			-0.478* (0.242)			-0.175 (0.246)
Agency MREIT*Fed MBS Purchase Share Taper			-0.244 (0.170)			-0.218 (0.159)
Macroeconomic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Institution Controls	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,000	1,000	1,000	474	474	474
R-squared	0.227	0.229	0.253	0.734	0.740	0.741
Number of Firm Clusters	50	50	50	25	25	25

Appendix A: Timeline of Federal Reserve Policy Actions Over the Period 2008—2014

The table presents the timeline of Federal Reserve Policy Actions relating to unconventional monetary policy discussed in Section 2.2. For each policy measure, the table indicates the announcement date, the target end date for the policy measure, the total target amount of asset purchases under the measure, the type of assets targeted, and program details as provided at the announcement. The data used are obtained from the Federal Open Market Committee meeting minutes.

	Announcement Date	Target End Date	Targeted Total Purchases	Composition of Purchases	Program Details as Announced
Quantitative Easing 1 (QE1) December 2008—March 2010	November 25, 2008	Over Several Quarters	Agency Debt: Up to \$100b Agency MBS: Up to \$500b	Agency Debt and Agency MBS	Purchase up to \$100b of Agency debt and up to \$500b of Agency MBS. Purchases expected to take place over several quarters.
	December 16, 2008	—	—	—	Lowered the Fed Funds rate to effective lower bound and stated that this was likely to remain for “some time”.
	March 18, 2009	Treasury Securities: September 30, 2009 (Completed Oct. 2009) Agency Debt & MBS December 31, 2009 (Completed Mar. 2010)	Agency Debt: Add \$100b Agency MBS: Add \$750b Long-Term Treasuries: \$300b	Agency Debt, Agency MBS, and Long-Term Treasuries	Total purchases of Agency MBS will now be up to \$1.25t and Agency debt up to \$200b. Purchase up to \$300b of long-term Treasury securities over the next six months. Rates likely to remain at the effective lower bound for an “extended period”.
Quantitative Easing 2 (QE2) November 2010—June 2011	November 3, 2010	June 30, 2011	Long-Term Treasuries: \$600b	Long-Term Treasuries	Purchase \$600b of long-term Treasury securities by the end of 2011:Q2 at a pace of about \$75b per month.
Policy Normalization Principles	June 22, 2011	—	—	—	
Maturity Extension Program (MEP) & Forward Guidance MEP: September 2011—December 2012	August 9, 2011	—	—	—	Rates likely to remain at the effective lower bound at least until mid-2013.
	September 21, 2011	June 30, 2012	Long-Term Treasuries: \$400b	Long-Term Treasuries	Purchase, by the end of 2012:Q2, \$400b of Treasuries with remaining maturities between 6-30 years and sell an equal amount of Treasury

					securities with remaining maturities of 3 years or less.
	January 25, 2012	—	—	—	Rates likely to remain at the effective lower bound at least through late 2014.
	June 20, 2012	December 31, 2012	Amount Limited by Remaining Short-Term Treasuries	Long-Term Treasuries	Purchase Treasuries with remaining maturities between 6-30 years at the current pace and sell or redeem an equal amount of Treasury securities with remaining maturities of approximately 3 years or less.
Quantitative Easing 3 (QE3) September 2012— December 2013	September 13, 2012	None Given	None Given	Agency MBS and Long-Term Treasuries	Purchase Agency MBS at a pace of \$40b per month and continue Twist through year-end, increasing holdings of long-term securities in aggregate by \$85b. Rates likely to remain at the effective lower bound at least through mid-2015.
	December 12, 2012	None Given	None Given	Agency MBS and Long-Term Treasuries	Purchase Agency MBS at a pace of \$40b per month and long-term Treasuries at a pace of \$45b per month after Twist ends at year-end. Rates likely to remain at the effective lower bound, but now conditional on economic indicators.
Tapering December 2013— December 2014	December 18, 2013	None Given	None Given	Agency MBS and Long-Term Treasuries	Purchase Agency MBS at a pace of \$35b per month and long-term Treasuries at a pace of \$40b per month after Twist ends at year-end.
	January 29, 2014	None Given	None Given	Agency MBS and Long-Term Treasuries	Purchase Agency MBS at a pace of \$30b per month and long-term Treasuries at a pace of \$35b per month after Twist ends at year-end.
	March 19, 2014	None Given	None Given	Agency MBS and Long-Term Treasuries	Purchase Agency MBS at a pace of \$25b per month and long-term Treasuries at a pace of \$30b per month after Twist ends at year-end.

	April 30, 2014	None Given	None Given	Agency MBS and Long-Term Treasuries	Purchase Agency MBS at a pace of \$20b per month and long-term Treasuries at a pace of \$25b per month after Twist ends at year-end.
	June 18, 2014	None Given	None Given	Agency MBS and Long-Term Treasuries	Purchase Agency MBS at a pace of \$15b per month and long-term Treasuries at a pace of \$20b per month after Twist ends at year-end.
	July 30, 2014	None Given	None Given	Agency MBS and Long-Term Treasuries	Purchase Agency MBS at a pace of \$10b per month and long-term Treasuries at a pace of \$15b per month after Twist ends at year-end.
	September 17, 2014	None Given	None Given	Agency MBS and Long-Term Treasuries	Purchase Agency MBS at a pace of \$5b per month and long-term Treasuries at a pace of \$10b per month after Twist ends at year-end. Issue revised Policy Normalization Principles, which suggest that the policy rate will be moved before reducing portfolio size.
	October 29, 2014	—	—	Agency MBS and Long-Term Treasuries	No additional purchases of Agency MBS and long-term Treasuries; maintain balance sheet size through reinvestment (as previous).
Rate Hike	December 2015	—	—	—	—