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Following the Money:
Evidence for the Portfolio Balance Channel of Quantitative Easing

Abstract

Recent research suggests that quantitative easing (QE) may affect a broad range of asset prices through a portfolio balance channel. Using novel security-level holding data of individual US mutual funds, we establish strong evidence that portfolio rebalancing occurred both within funds and across funds around Federal Reserve QE purchases. We find that mutual funds replaced QE securities with other government bonds that have similar characteristics; intriguingly, the shift was mainly into newly issued government bonds. Such within-fund portfolio rebalancing is material. For every $100 in QE bonds sold, mutual funds replenished their portfolios with about $50 to $60 of newly issued government bonds. In comparison, portfolio rebalancing by fund managers into riskier assets is much smaller in magnitude. Instead, the portfolio rebalancing into riskier assets, such as corporate bonds, did occur, but mainly through the end investors. We find a significant shift into corporate bond funds initiated by the end investors of mutual funds instead of fund managers. Such across-fund portfolio shift is sizable. Corporate bond funds received more than $50 billion of additional assets in inflows during the QE period, relative to government bond funds.

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I see the evidence as most favorable to the view that such purchases work primarily through the so-called portfolio balance channel, which … relies on the presumption that different financial assets are not perfect substitutes in investors' portfolios … For example, some investors who sold MBS to the Fed may have replaced them in their portfolios with longer-term, high-quality corporate bonds, depressing the yields on those assets as well.

— Ben Bernanke, Jackson Hole, August 27, 2010

1. Introduction and related literature

Quantitative easing (QE), as an unconventional monetary policy tool, was used widely by many central banks in advanced economies since the onset of financial crisis, including the Federal Reserve, the Bank of England and the European Central Bank (ECB). While the objectives of QE purchases were to revive the economy and bring inflation back to its target, debates remain over how the policy would work. Over the past few years, there has been a surge of empirical and theoretical research that aims to identify the transmission mechanism of QE.

Policy-makers have consistently emphasized the role of the portfolio balance channel as a key element in the expected transmission of asset purchases to the rest of the economy (see, e.g., Bean 2011 for the Bank of England, Yellen 2011 for the Federal Reserve and Praet 2015 for the ECB). Theoretical models can also demonstrate the portfolio balance channel of QE in the presence of market segmentation and/or capital constraints (see Vayanos and Vila 2009; Gertler and Karadi 2011; He and Krishnamurthy 2013; and Del Negro et al. 2013). According to this channel, by purchasing a large quantity of assets held by the private sector through QE, central banks change the relative supply of the assets being purchased and thus induce changes in their relative yields. Since the base money issued and the financial assets purchased under QE are not perfect substitutes, the sellers of financial assets may attempt to rebalance their portfolios by buying other assets that have similar characteristics to the assets sold. This process, therefore, further pushes up not only the prices of the assets purchased under QE, but also the prices of their close substitutes, and brings down the associated term premiums and yields.

Most of the empirical evidence on the existence of the portfolio balance channel has come from event studies around QE announcements. For example, US QE announcements are associated with a reduction in international bond yields and the US dollar (e.g., Neely 2015), as well as corporate bond yields (Gagnon et al. 2011). ECB QE has had a significant impact German government yields (Andrade et al. 2016).[1] These announcement effects could be attributable to either the portfolio balance channel or a signalling channel. The former should reduce the term premia component of longer-term yields, whereas the latter should reduce expectations of future short-term interest rates. Different studies have offered support for one channel or the other. For example, Bauer and Rudebusch (2014) and Glick and Leduc (2011) both attribute reactions to a signalling of lower future short-term rates. The results often hinge on the asset-pricing model used to decompose yields into risk-premium and expectations components.[2]

We make an important departure from the above existing literature by directly examining the security-holding positions of each mutual fund during QE. More precisely, to test for the presence of the portfolio channel, we analyze how QE alters the quantities of individual securities held by mutual funds. We study mutual funds instead of banks for two reasons. First, while it is clear that banks played a crucial role in the transmission of QE, other sectors, such as mutual funds and pension funds, also played an essential role as ultimate sellers of the QE assets.[3] To put things in perspective, the Federal Reserve purchased $600 billion in Treasury securities as part of its second QE program alone, much larger than the banking sector's aggregate Treasury holdings of about $100 billion in 2008 (Federal Reserve Flow of Funds).[4] Second, the unique dataset of security-by-security-level holdings of individual mutual funds in the US can provide a detailed account about how money moved around within and across funds during the QE period. Such level of detail in the holding position is impossible to obtain for major banks. Therefore, we use US mutual funds as a laboratory to study the portfolio rebalance channel of QE.

To our knowledge, only a few studies investigate the portfolio balance channel of quantitative easing through fund level data.[5] Joyce, Liu and Tonks (2014) use micro-level data on

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[1] In contrast, Swedish QE announcements had a negligible impact on local and global term premia, because these purchases were small compared with a large pool of highly substitutable securities (Diez de los Rios and Shamloo 2017).
[2] Rebalancing could induce a local supply effect, whereby yields within a particular maturity sector are more sensitive to changes in the outstanding supply in their maturity than to changes in that of other sectors (Krishnamurthy and Vissing-Jorgensen 2011, 2012; D'Amico and King 2013; Joyce et al. 2014). Alternatively, by removing aggregate duration risk from private sector portfolios, central bank purchases can lower the risk premium for holding duration risk (Gagnon et al. 2011).
[3] For example, Kandrac and Schlusche (2016), Christensen and Krogstrup (2016a, 2016b), Chakraborty, Goldstein and MacKinlay (2016) and Daetz et al. (2016) all investigate the impact of QE through the banking channel.
[4] Mutual funds, in contrast, held almost twice the amount of banks.
[5] In an innovative set-up, Karolyi and McLaren (2016) consider the impact of fund flows around the May 2013 Federal Reserve tapering announcement on those funds' emerging-market stock holdings. Security returns following the tapering announcement are positively related to the change in holdings of the security implied by mutual fund flows around the announcement. However, given that the stock funds likely held few QE securities, the flow-driven effects Karolyi and McLaren (2016) find may be more related to a signalling of higher interest rates rather than the portfolio balance channel.

UK pension funds and insurance companies to investigate the portfolio balance effect around UK QE announcement dates. Carpenter et al. (2013) use US Federal Reserve Flow of Funds data to investigate how different sectors responded to Federal Reserve asset purchases. The advantage of our study relative to Joyce, Liu and Tonks (2014) and Carpenter et al. (2013) is that we can identify the mutual funds that hold the specific securities purchased by the Federal Reserve each quarter, which enables us to pin down the effects of QE on fund portfolio decisions. At a fund level, we can measure its holdings of each security to estimate each fund's exposure to CUSIP-level QE purchases every quarter. Due to the nature of their data, these studies cannot measure whether funds were holding the specific securities purchased by the Bank of England or Federal Reserve and cannot see rebalancing if a fund sells one government bond (being purchased through QE) and purchases another government bond. Using our method, we can examine whether funds that have a higher exposure to QE purchases sell those securities and, if they do sell, where they invest the proceeds. We believe this method can "follow the money" and identify the effect of QE purchases on mutual fund portfolios.

Koijen et al. (2016, 2017), like us, take advantage of detailed security-level holdings data. Their security-level data is broader than our data in that it covers all sectors of the euro-area economy (e.g., pension funds, banks, foreign holdings), and they have holdings of each of these sectors at the country level. Koijen et al. (2016, 2017) examine changes in risk exposures for various sectors, and see how the ECB's expanded asset purchase program (i.e., ECB QE) affected sectors in a group of vulnerable and not-vulnerable countries. They find that, in Europe, foreign investors and banks were the large sellers during the ECB's expanded asset purchase program (Koijen et al. 2017). Mutual funds in Europe rebalance out of eligible bonds following QE, but their amount of rebalancing is not abnormal relative to the amount of rebalancing expected of them if they sold the same fraction of their portfolio as the aggregate investor.

Albertazzi, Becker and Boucinha (2016) use the same dataset and focus on how the ECB's QE program affects country/sector-level holdings of assets. They quantify a sector's exposure to QE by measuring the return of each sector's portfolio around the announcement of the ECB's asset purchase program. Their methodology assumes that rebalancing incentives are proportional to the change in the value of the portfolio; for example, their methodology suggests sectors that experience a larger yield decline have more incentive to rebalance to higher-yielding securities.

Albertazzi, Becker and Boucinha (2016) concentrate on newly issued debt securities since rebalancing in an outstanding security by one investor must be offset by portfolio rebalancing by another investor in the opposite direction. Overall, they do not find that exposure to QE is related to rebalancing into newly issued securities in the euro area as a whole. But, they do find some rebalancing towards corporate bonds in a subset of more vulnerable economies.

We differ from these studies along several dimensions. First, we focus on all of the US QE programs, rather than the ECB and Bank of England programs. A priori, the effect of QE could be very different in the US since the supply of government bonds increased much more in the US than it did in the euro area. A priori, we would expect less rebalancing into corporate bonds and other risky assets and more rebalancing into newly issued government bonds. Indeed, we find that for every dollar's worth of QE securities sold by a fund, about 75 cents were rebalanced into government securities, a large portion of which were newly issued securities. This suggests that there was less scope for the portfolio balancing to corporate bonds in the US, since many funds were simply replacing QE bonds with other government bonds. We confirm the findings of Koijen et al. (2016) that mutual funds sell similar to the aggregate investor. We find that mutual funds sell both Agency MBS and Treasury securities in the quarters those securities are purchased by the Federal Reserve. When an Agency security held by mutual funds is purchased through QE, mutual funds reduce their holdings of that security by just over 20%. Mutual funds reduce their individual Treasury holdings by around 10% when the Federal Reserve purchases that security, roughly equal to the proportion of individual security supply the Federal Reserve removes from the market in these Treasury purchases.

Second, although our mutual fund data is not as broad, it is more detailed. Rebalancing occurs not only within a fund but also across funds. Within funds, we can see how differences between individual funds affect portfolio rebalancing. Although our study focuses on mutual funds, it can show the extent to which constraints impact portfolio rebalancing. Some funds are less flexible and have narrow mandates. Fund mandates may prevent them from holding the securities purchased through QE, or prevent them from purchasing non-QE assets. As expected, there is less rebalancing occurring within these funds. They behave much like preferred habitat investors (Vayanos and Vila 2009). Nonetheless, they still rebalance at about half the intensity of less-constrained funds. But the narrow-mandate funds rebalanced into other government bonds. In contrast, funds with broader mandates (e.g., those that benchmark their performance against an index that spans different fixed-income sectors, such as corporate bonds and government bonds) sold more QE-purchased securities and reinvested a portion of their proceeds into other fixed-income sectors, such as corporate bonds and ABS.

Another advantage of our set-up is that we can also track how investors in the funds respond to quantitative easing: i.e., how rebalancing occurs across funds rather than within funds. Despite the fact that narrow-mandate funds were constrained and had little scope to rebalance their portfolios, investors in these funds did the rebalancing for them. In a difference-in-difference analysis, we find that, in QE quarters, investors reduce their exposure to funds focused on government securities and increase their exposure to corporate bond funds. In QE quarters, corporate funds received an increase of 3% of assets in net flows, relative to government bond funds. Considering the duration of QE in the US, this fund flow effect is economically large, and purchases of corporate bonds driven by these fund flows are orders of magnitude larger than the purchases of corporate bonds driven by within-fund rebalancing. Thus, although fund mandates constrain the ability of funds to deviate too much from their benchmark portfolios, portfolio rebalancing is occurring at the investor level. Investor fund flows can have real effects on firms. Edmans, Goldstein and Jiang (2012), for example, show that mutual fund redemptions can lead to firm valuation decreases, exposing them to a higher probability of a takeover.

2. Data and methodology

To understand mutual fund portfolio balancing behaviour in response to Federal Reserve asset purchases, we combine two securities-level datasets. The first contains information at a quarterly frequency of the individual securities holdings of bond mutual funds. The second dataset identifies Federal Reserve asset purchases of individual securities from changes in the quarterly holdings of the Federal Reserve's System Open Market Account (SOMA) portfolio holdings. From the interaction of these two data sources, we can analyze how mutual funds' holding of securities that the Fed is purchasing affects the mutual fund's portfolio decisions.

2.1 Mutual fund portfolios

We extract information on the quarterly securities holdings of mutual funds from Morningstar. Our sample period begins in 2006 Q1, prior to QE by the Federal Reserve, and ends in 2014 Q3, just as the Federal Reserve was finishing its tapering of its QE. Our study is concerned with bond mutual funds, which we define as any fund that holds at least 70% of its (non-derivative) securities classified as bonds by Morningstar. We also exclude Municipal bond funds: those that hold more than 90% of their portfolio in Municipal securities or have a Municipal index as their benchmark. After these filters, our sample contains 896 bond funds. We focus exclusively on the bond holdings of these bond funds.

From **Table 1a**, there is a wide variety in fund mandates. We base this classification on the benchmark indexes of the funds in our sample.[6] On the one hand, some funds appear to have more narrow objectives and may be considered as preferred habitat investors. We find 170 funds in the sample are "pure" government funds, benchmarking against a US government index. On average, these funds hold about three-quarters of their portfolio in Treasury and Agency securities. But they do also invest in other asset classes, such as securitizations and corporate bonds. There are also some funds that hold almost no government securities but have a mandate to focus on corporate bonds (192 funds) or international securities (65 funds). When the Federal Reserve conducts QE, these funds may be less likely to adjust their portfolios because of their strict mandates. The corporate and international funds hold, on average, less than 5% of their portfolios in government securities, so do not have many assets to sell to the Federal Reserve. The pure corporate bond funds, for example, mostly hold corporate and international bonds. The "pure" government funds are unlikely to sell to the Federal Reserve and buy bonds outside their mandates. On the other hand, there are a large number of funds that have wider mandates and invest across a variety of asset classes. These may be considered arbitrageurs in the Vayanos and Vila (2009) setting. There are 460 funds that have a broad benchmark index. These funds, on average, invest about 25% of their portfolios in corporate bonds, about 30% in government and Agency securities and about 15% in international bonds.

[6] A small number of funds do not report a benchmark index. For these funds, we classify them based on their average portfolio allocations over the sample period. For example, funds with average allocations greater than 95% to government and Agency securities would be classified as "pure" government.

For each of these bond funds, Morningstar provides securities-level data on the holdings of the bond. This includes the bond's name and CUSIP, the market value of the bond, the par value of the bond, the bond's coupon rate and the bond's maturity. Given this information, we also calculate the yield to maturity (ytm) of each bond assuming semi-annual coupon payments.[7] We also calculate the bond's credit spread by subtracting the Treasury zero coupon yield for the bond's maturity from this yield to maturity. We obtain zero coupon Treasury bond yields for the 1 month, 3 month, 6 month, 1 year, 2 year, 3 year, 5 year, 7 year, 10 year and 30 year from the Federal Reserve Board's H15 Bulletin, available through their website. For each bond, we interpolate between the two nearest maturities to determine the appropriate reference Treasury yield in calculating the spread.

Following other research, we back out mutual fund flows using the change in the total net assets of fund *j* (TNA) at time *t*, as well as its return (see, e.g., Coval and Stafford 2007). This assumes that the flow is equal to the percentage change in the fund's assets under management, less the fund's return:

$$Flow_{j,t} = \frac{TNA_{j,t}}{TNA_{j,t-1}} - (1 + RETURN_{j,t}) \tag{1}$$

We calculate the fund return using the appreciation of the fund's individual bonds (i), weighted by the size of each bond's market value (MV) in the fund's overall portfolio.

$$RETURN_{jt} = \frac{\sum_i MV_{i,j,t-1} * \frac{PRICE_{i,j,t}}{PRICE_{i,j,t-1}}}{TNA_{j,t-1}} - 1 \tag{2}$$

We are interested in how allocations to different sectors change as a result of QE. The change in the dollar allocation to an individual bond (which can then be aggregated to the sector level) can be calculated from the bond's par value and price. Essentially, we are measuring the change in the holdings of the bond, assuming the price was constant at its current level:

$$\Delta ALLOCATION_{ijt} = (\text{PAR VALUE}_{ijt} - \text{PAR VALUE}_{ijt-1}) * \text{PRICE}_{ijt} \tag{3}$$

[7] Specifically, we find the value of ytm that solves the following formula: $Price = \frac{coupon}{ytm}\left(1 - \frac{1}{\left(1+\frac{ytm}{2}\right)^{2*maturity}}\right) + \frac{1}{\left(1+\frac{ytm}{2}\right)^{2*maturity}}$. We are unable to calculate the yield to maturity for non-USD bonds since the bond price is in US dollars and par value is in local currency. Yields to maturity below -1% or above 50% are considered outliers and are replaced with missing values.

Flows must result in a change in allocation to different sectors. It is easy to show that the fund flows defined above can also be expressed as

$$Flow_{j,\,t} = \frac{\sum_i \Delta ALLOCATION_{i,j,t}}{TNA_{j,t-1}} \tag{4}$$

A fund may change its allocation to a given bond or sector if it receives inflows or outflows. We assume that a fund will proportionally invest (divest) any inflows (outflows) it receives. The abnormal allocation to a bond is therefore the allocation change beyond that which would be expected given the flows the fund received:

$$\%\Delta Abnormal\ Allocation_{\,i,\,j,\,t} = \frac{\Delta ALLOCATION_{i,j,t}}{TNA_{j,t-1}} - Flow_{j,\,t} * \frac{MV_{j,t-1}}{TNA_{j,t-1}} \tag{5}$$

For a given sector *s* (e.g., corporate bonds), the abnormal allocation change is simply the sum of the abnormal allocation change of all bonds within that sector. For each time period and fund, the sum of these abnormal allocation changes should sum to zero (this can be seen by first summing over equation (5) and substituting in equation (4)). We also define two other variables at a fund level. The first is $\%SOMA_{jt}$, which is the proportion of fund *j*'s assets invested in a security at time *t* that the Federal Reserve has, at some point in our sample period, held in its SOMA portfolio. The second is $\%\ QE_{jt}$, which represents the proportion of fund *j*'s assets invested in a security at time *t* that the Federal Reserve is buying during the quarter between *t* and *t* + 1.

2.2 Federal Reserve Purchases

We obtain the par value of the Federal Reserve's SOMA portfolio individual Treasury and Agency securities holdings at each quarter-end from the Federal Reserve Bank of New York's website. In addition to the amount of each individual Treasury security held in the SOMA account, the Federal Reserve also provides the total outstanding amount of each Treasury security in its portfolio and hence the proportion of the total outstanding that is held in the SOMA account.[8]

Given the large number of Agency securities in its portfolio, the Federal Reserve consolidated similar Agency MBS securities into larger pass-through securities using a CUSIP aggregation service provided by Fannie Mae and Freddie Mac.[9] The Federal Reserve aggregated

[8] Outstanding amounts are not available for Agency securities.
[9] https://www.newyorkfed.org/markets/opolicy/operating_policy_150731.html

CUSIPs to reduce operational costs and the complexity of managing a large number of individual Agency MBS CUSIPs. Using the Federal Reserve's mapping list of every Agency MBS CUSIP underlying an aggregated CUSIP, we consolidate securities and perform all of our analysis at the aggregated CUSIP level.

From this information, we can determine whether the Federal Reserve is buying a security as part of its QE programs in a given quarter. The Federal Reserve did not hold any Agency securities in its SOMA account in our sample period before QE1, so if the SOMA holdings of a SOMA Agency security increase in a given quarter, we classify the Federal Reserve as buying that Agency security as part of its QE program in that quarter.

For Treasury securities, it is not as straightforward to determine whether a security is purchased by the Fed as part of its QE programs for two reasons. First, the Federal Reserve may increase the holdings of an individual security because it is reinvesting the proceeds of its SOMA holdings that are maturing into other securities within its portfolio. For example, in 2006, the Federal Reserve increased its holdings for a large proportion of the Treasury securities in the Federal Reserve SOMA portfolio, well before it implemented its QE program. Second, although the Federal Reserve is purchasing some securities into its SOMA portfolio, it may not be necessarily reducing the net outstanding supply of that security if the US Treasury is issuing more of that security at the same time. To overcome these challenges, we apply two filters in classifying a positive increase in the SOMA portfolio holdings as a QE purchase. First, we require that the Federal Reserve purchase at least 5% of the total outstanding supply of the Treasury security in that quarter. This eliminates the problem of classifying small portfolio changes as QE and also focuses the analysis on purchases that are likely to have a market impact. Second, we also contrast the Federal Reserve purchases with the amount of Treasury issuance in that quarter and require that the Federal Reserve purchases exceed any Treasury issuance of the security. This ensures that the asset purchase is decreasing the public supply of the security.

2.3 The combined dataset

Using each security's CUSIP, we map the Federal Reserve purchases to the Morningstar mutual fund holdings. The resulting dataset contains 328,166 individual securities, the majority of which are Agency securities (**Table 1b**). The reason for the large number of individual Agency securities in our sample is that the Agency securities are smaller in size: the average aggregate (across all funds) position size is $4.5 million. This contrasts against the 1,360 Treasury securities in the sample, which have an aggregate (again, across all funds) position size of $545 million. Only 7.6% of the individual Agency security CUSIPs held by mutual funds were held in the Federal Reserve's SOMA portfolio at some point in time during our sample period. By contrast, 42% of the individual government bond CUSIPs held by mutual funds were in the Federal Reserve's SOMA portfolio at some point during the sample period.

From **Figure 1**, we can see how mutual fund holdings of Agency and Treasury securities were affected by the Federal Reserve's three QE programs. The Federal Reserve announced its first QE program (QE1) in November 2008. The initial objective of the program was to purchase up to $600 billion in Agency MBS and Agency debt. The program was later expanded in the first quarter of 2009 to purchase an additional $850 billion in Agency debt and Agency MBS as well as $300 billion in Treasury securities. In its transactions, the Federal Reserve made QE purchases (as we have defined them earlier) in about 10% of the individual Treasury CUSIPs and just over 1% of the individual Agency securities held by mutual funds during QE1. This figure is much smaller since the number of Agency securities outstanding from which to purchase (and held by mutual funds) is much larger, and since the QE purchased concentrated on a subset of Agency securities, namely fixed-rate Agency MBS securities guaranteed by Fannie Mae, Freddie Mac and Ginnie Mae.

From the end of 2010 to the middle of 2011, in its second QE program (QE2), the Federal Reserve committed to buying $600 billion of Treasury securities, aiming to acquire about $75 billion each month. QE2. Again, given the focus on longer maturity Treasuries, these Treasury purchases represented about 10% of the individual CUSIPs held by mutual funds. Finally, from September 2012 through the end of 2013, the Federal Reserve implemented its third QE program (QE3). After upsizing the program in December 2012, the Federal Open Market Committee authorized $45 billion in monthly Treasury purchases and $40 billion in monthly Agency security purchases. In its Treasury security purchases, this program was smaller than QE2 and focused on a smaller subset of securities, affecting less than 5% of mutual fund CUSIPs. Conversely, QE3 had a larger impact on the number of Agency CUSIPs held by mutual funds. Post QE3, the Federal

Reserve continued to reinvest principal from maturing Agency securities in its portfolio into (mostly) newly issued Agency securities.

3. Quantitative easing and mutual fund behaviour

Using mutual fund portfolios, we investigate two prerequisites for there to be support for the proposition that the Federal Reserve QE programs work primarily through the portfolio balance channel. First, when the Federal Reserve purchases assets, some participants need to be selling assets. For the portfolio balance channel to work through mutual funds, these funds should be net sellers of the assets the Fed is purchasing. Second, if funds do sell securities when the Federal Reserve is purchasing them, which securities do funds rebalance their portfolio towards? If they sell one Treasury to the Fed only to buy another similar Treasury, this would suggest that the portfolio balance channel should have little effect on non-government yields. In contrast, the evidence of the portfolio balance channel would be stronger should they reallocate towards corporate and international bonds. In this analysis, we control for fund flows. It is also possible that mutual fund investors rebalance their portfolio around QE purchases. For example, investors could reduce their allocation to Treasury funds and increase their allocation to corporate or international funds. Therefore, we also examine the link between fund flows and QE.

3.1 How do mutual funds rebalance when the Federal Reserve is buying their Treasury and Agency securities?

If mutual funds sell the Treasuries and Agencies that are being purchased via QE, funds could either increase their cash or increase the allocation to other securities with the sale proceeds. We begin by analyzing portfolio allocations at a fund level, and then look to a security-level analysis to confirm our findings at the fund level.

3.1.1 Fund-level allocations by asset class

To investigate the portfolio balance behaviour of mutual funds induced by QE, we classify funds based on their exposure to QE purchases. Each quarter, we measure the proportion of the fund's market value that is invested in securities that the Federal Reserve is purchasing. We then divide those funds that have some exposure to QE purchases into quintiles, with funds in the first quintile having the lowest exposure and funds in the fifth quintile having the highest exposure. From **Table 2**, Panel A, funds in quintile 1 have a small (0.5% of their portfolio) exposure to QE purchases, while funds in quintile 5 have about 15% of their portfolio invested in securities the Federal Reserve is purchasing that quarter. Part of the reason these funds have a higher exposure is that they focus more on government securities – the lowest quintile has about 15% of its portfolio invested in SOMA, compared with almost half of the portfolio invested in SOMA securities in the highest quintile.

Funds with more exposure to QE purchases sell more of the securities that the Federal Reserve is buying. This can be seen from changes in funds' allocations to QE securities. We measure this allocation change as the dollar change in the fund allocation, as a percentage of the end of the prior quarter's fund assets, less the fund allocation change that could be expected to occur based on fund flows.[10] While there is practically no observable change in fund allocation to QE securities in quintile 1, funds in the highest quintile sell QE securities equal to 2.9% of their assets, on average. This is a substantial amount and represents almost 20% of their holdings of these QE securities.

This result is not likely driven by endogeneity; the Federal Reserve was not targeting assets that mutual funds would be more likely to sell. Federal Reserve purchases were conducted by auction. Each month, the Federal Reserve would announce its anticipated Treasury purchases, along with details such as the total amount of assets to be purchased, the types of securities to be purchased as well as the range of securities it would be purchasing in the following month. Within this framework, the amount the Federal Reserve purchases of a specific security depends on the attractiveness of offers submitted by dealers relative to secondary market prices of similar securities and an internal, spline-based price (Sack 2011). The Federal Reserve paid a very small premium above secondary market ask prices in its Treasury auctions, with a higher premium for "cheap" bonds (Song and Zhu 2017). Agency purchases were carried out through an external investment manager, with an initial focus on off-the-run securities (Gagnon et al. 2011).

Our results suggest that most of the proceeds flow to other government securities – representing most of the portfolio balance effect. Quintile 5 funds allocate 2.3% of their portfolio, on average, to non-QE Agency and Treasury securities, which is almost as much as the 2.9% of their portfolio in QE assets that they sold. There does not seem to be any portfolio balancing into international securities at the fund level, given that the allocation changes across the five quintiles

[10] We measure this flow-implied fund allocation by multiplying percentage fund flows by the percentage of the fund's assets invested in the asset class in the prior quarter.

appear similar. On the other hand, allocations to corporate bonds become marginally higher as funds become more exposed to QE. Although these results suggest that a bulk of the portfolio balance translated into purchases of other government securities, the division of funds into quintiles captures funds with a higher allocation to government securities that may be more predisposed to rebalance into government securities. One way to attack this question is to examine different types of funds. We repeat the analysis for mixed funds and pure funds, as defined in **Table 1**. Mixed funds should be less constrained and should be more likely to rebalance into other, non-government securities all else being equal. Mixed fund types do seem to exhibit more rebalancing behaviour (panels B and C). The mixed funds in quintile 5 sell more QE securities than their pure fund counterparts. Further, pure funds show no increasing allocation to corporate bonds across quintile, so the full sample results are driven by the rebalancing behaviour of mixed funds. Thus, these summary statistics suggest that constraints may matter for mutual fund portfolio rebalancing. Notwithstanding this different behaviour, mixed funds seem to be also rebalancing most of their QE proceeds into government securities.

We examine this relationship more formally in **Table 3**, running fund-level regressions of changes in abnormal portfolio allocations to each sector *s* on the fund's exposure to QE.

$$\%\Delta Abnormal\ Allocation_{sjt} = \alpha + \beta_1\ \%SOMA_{jt-1} + \beta_2\ \%\ QE_{jt-1} + \beta_3\ Flow_{jt-1} + \beta_4\ Return_{jt-1} + \gamma_i + \epsilon_t + \varepsilon_{it} \quad (6)$$

By construction (apart from some minor differences due to winsorizing), the sum of the *%ΔAbnormal Allocation* across the different asset classes should equal zero for each fund. That is, if a fund allocates more to one asset class, it must allocate less to another (recall that this abnormal allocation measure subtracts off the expected change due to fund flows). Given that this identity holds in the data, it also implies that the coefficients across the different regressions should sum to zero as well (Chang, Dasgupta and Wong 2010).

Our coefficient of interest in the above regression is that associated with *%QE*, the proportion of each fund's portfolio invested in securities that the Federal Reserve was purchasing in the given quarter. *%SOMA* is included as a control to account for the regular portfolio reallocations that may be expected to occur given a fund's holdings of government bonds. This variable measures the proportion of each fund's portfolio invested in bonds that were ever held by the Federal Reserve. If a fund has a higher proportion of its portfolio invested in government bonds in a given quarter (relative to its average holdings), it may want to reduce its exposure in the following quarter. We include flows between the previous quarter and the current quarter, since funds may allow inflows and outflows to have a temporary effect on its portfolio allocations. For example, a fund may choose to use more liquid securities, such as government bonds, to minimize liquidity costs associated with investor turnover (e.g., Zeng 2016; Chernenko and Sunderam 2015). Finally, the fund's lagged return is also included to account for the possibility that bond mutual funds could be positive feedback traders (e.g., Froot, Scharfstein and Stein 1992; Bohn and Tesar 1996).

Consistent with the evidence in the quintile analysis, pure funds (those with a benchmark covering a single asset class such as Treasuries or corporates) are net sellers of QE securities in the quarters the Federal Reserve is purchasing those individual securities. This can be seen in the third column of **Panel A**, titled Abnormal QE Government Allocation. The statistically significant, negative coefficient of -0.162 on *% QE* implies that pure mandate funds reduce their allocation to these securities by about 16%. In the fourth column, Abnormal Non-QE Government Allocation, the coefficient is about the same magnitude but of opposite sign. Thus, all of the proceeds of the sale of these funds of QE securities flow into other government securities (Agency MBS and Treasuries) that the Federal Reserve is not purchasing that quarter. For the other asset classes, this coefficient is much smaller and is only statistically significant in one case (Abnormal International Allocation). The coefficient on *%SOMA* across the asset classes is consistent with funds' normal rebalancing of their portfolio. In the quarter following a higher exposure to SOMA securities (i.e., government securities), funds reduce slightly their allocation to non-QE government securities (-0.056 coefficient in column 4) and increase their allocation to most of the other asset classes. In addition, following a period of higher fund flows, funds increase their allocation to liquid asset classes (cash and government) and reduce their allocation to the less-liquid asset classes (international, corporate and other).

Since mixed funds are less constrained than pure funds (they have broader benchmarks), they should behave more as arbitrageurs than preferred habitat investors, and our results confirm this. The effect of QE purchases in mixed funds (those with a mandate spanning multiple asset classes) is even stronger. They reduce their allocation to the securities the Federal Reserve is purchasing in the current quarter by more than 30% given the statistically significant, negative coefficient of -0.313 on *% QE* (**Panel B**, column 3). Again, funds put most of the proceeds of the sale into government securities that are not QE purchases in the current quarter (coeff. = -0.295, column 4). There is some evidence in these regressions of a substitution into corporate securities. The positive and significant coefficient on *% QE* suggests funds increase their allocation to corporate securities when they are exposed to more QE purchases. In terms of economic significance, a mixed fund that holds 30% of its portfolio in securities the Federal Reserve is purchasing would increase its allocation to corporate securities by 0.8% (30% X 0.025). This is similar in magnitude to the quintile results in **Table 2**. Also consistent with the quintile results, the fund-level regressions do not suggest a relation between changes in allocations to international securities and QE.

3.1.2 Effect of Agency MBS vs. Treasury bond purchases

Federal Reserve Agency and Treasury purchases engender similar responses on the part of pure funds, in that the proceeds of QE-related Treasury (Agency) sales are reinvested into other non-QE Treasury (Agency) securities. To evaluate these securities separately, we re-estimate Equation (6), but instead of combining Agency and Treasury QE purchases into a single variable, they are represented as individual variables. Further, we now investigate the abnormal allocations to these categories separately (**Table 4**). As before, we analyze pure funds first. These funds exhibit similar selling behaviour for Agency and Treasury QE purchases. The abnormal QE Agency allocation has a coefficient of -0.162 on *% QE Agency*, and the abnormal QE Treasury allocation has a -0.168 coefficient on *% QE Treasury*. This suggests that, whether the Federal Reserve is purchasing Agency or Treasury securities, pure funds sell slightly more than 15% of their holdings of these securities in the same quarter. These funds tend to reinvest the proceeds mainly into the same type of securities that the Federal Reserve is not purchasing in the current quarter. For example, the abnormal non-QE Treasury allocation has a 0.174 coefficient on *% QE Treasury*, opposite in sign and similar in magnitude to the same coefficient on abnormal QE Treasury allocation. We also include an extra lag of the *%SOMA Agency*, *%SOMA Treaury*, *% QE Agency* and *% QE Treasury* variables. Only one of these extra variables is significant, suggesting there are minimal changes to allocations in the quarter following QE in pure funds. The lone coefficient of significance is the effect of the lag of *% QE Agency* on abnormal QE Treasury allocation, but this effect is small and opposite in sign but equal in magnitude to the concurrent effect of *% QE Agency* on this allocation. This suggests that the small effect of QE Agency purchase on the allocation towards Treasuries is reversed in the following quarter, consistent with these Treasury securities as a source of liquidity where some of the proceeds from Agency sales are temporarily parked.

Mixed funds sell more QE securities, and invest Agency and Treasury proceeds differently. The abnormal QE Agency allocation has a coefficient of -0.240 on *%QE Agency*, and the abnormal QE Treasury allocation has a -0.428 coefficient on *%QE Treasury*. Thus, these funds sell upwards of 40% of their Treasury securities that the Federal Reserve is purchasing in the same quarter of the purchase. For Treasury QE, practically all of these purchases are redirected into non-QE Treasuries. Thus, there is only a small amount of portfolio rebalancing into other asset classes: the abnormal corporate allocation is the only other asset class that has a positive coefficient on *%QE Treasury*. A couple of asset classes (abnormal international allocation and abnormal cash allocation) have a negative coefficient on this variable, but this impact is transitory, as the coefficient on the lag of this term is opposite in sign and similar in magnitude in each case. For Agency securities, only about half of the proceeds are reinvested in other Agency securities, with the other half invested in non-QE Treasury securities (coefficients on *%QE Agency* of 0.118 and 0.119, respectively). This suggests that there is not much rebalancing within funds into riskier securities. However, a small amount of rebalancing may be occurring, given that mixed funds increase their allocation towards other securities (e.g., ABS, non-Agency MBS) in the quarter following exposure to Federal Reserve QE Agency purchases, as evidenced by positive and statistically significant coefficient on the extra lag of *% QE Agency* (0.060).

3.1.3 Fund allocations within non-QE government securities

Given that the majority of the proceeds from their QE-related sales are reinvested into non-QE Treasury and Agency securities, we explore fund allocations into this category in greater detail. We focus on newly issued government debt for a number of reasons. First, Federal Reserve purchases occurred at a time when there was a significant amount of Treasury issuance by the US government. It seems likely that a large amount of portfolio rebalancing by investors in the US would inevitably result in purchases of newly issued government securities, leaving little room for rebalancing into riskier asset classes. Second, Federal Reserve Agency MBS focused on newly issued "production" Agency MBS. By providing a liquid market for newly issued securities, the purchases may help contribute to the reduction in primary mortgage rates (Gagnon et al. 2011). Thus, our analysis can help to understand the extent to which follow-on transactions by intermediaries such as mutual funds helped contribute to a liquid primary market.

Specifically, we subdivide non-QE Treasury and Agency securities into newly issued government bonds and previously issued bonds. In our analysis, we partition the allocation into non-QE government securities into allocations into "new" and "old" securities. A "new" security is newly issued, and we identify these from mutual fund holdings. A security is defined as "new" when the security first appears in our sample of mutual fund holdings in the current quarter or in the previous quarter.[11] After this, the security is considered previously issued and classified as "old."

Similar to Table 2, **Figure 2** examines abnormal allocation changes by funds' exposure to QE. Regardless of exposure level, funds reallocate from previously issued to newly issued government securities. This rotation is happening for three reasons. First, some of the bonds in the funds' portfolios are maturing and need to be replaced. Second, bond maturities shorten over time, and this shortening may move the bond out of funds' mandates or investment objectives. For example, some funds may not hold a bond until maturity but may sell the bond once its maturity falls below one year, given that bonds are removed from their benchmark indexes once a bond has less than one year to final maturity. Third, newly issued benchmark government bonds are more liquid, and funds may prefer to rotate their portfolio to these newly issued bonds once they become benchmarks.

Funds allocate a large portion of their QE proceeds into newly issued government securities (**Figure 2**). As funds have more QE exposure (i.e., moving from quintile 1 to quintile 5), they invest even more in newly issued non-QE government bonds. First-quintile funds allocate a little over 2% of their portfolio towards newly issued, non-QE government securities, while fifth-quintile funds allocate more than 5% of their portfolio. Part of this increase in portfolio allocation is coming from QE securities the funds sell, as fifth-quintile funds sell about 3% of their portfolio worth of QE securities. Meanwhile, allocation out of non-QE previously issued government securities increases from just over 2% in the first quintile to just under 4% in the fifth quintile. Thus, the net proceeds of the QE security sales appear to be going towards newly issued government securities. However, funds that have more exposure to QE also hold more government securities, so may be expected to rebalance more out of previously issued securities into newly issued non-QE government securities. Simply put, in a counterfactual scenario absent QE

[11] We do not have access to good reference data on Agency securities, so we use mutual fund holdings to identify when a security was newly issued. While not a perfect measure, if no single fund in our sample held the security in prior quarters, we take this as a good indication that the security is newly issued.

purchases, the funds in the fifth quintile may have sold even more previously issued government securities. Thus, from the figure one cannot ascertain whether QE resulted in less sales of previously issued government securities, more purchases of newly issued government securities, or a combination of the two.

We investigate this possibility in more detail in a regression analysis (**Table 5**). We divide the abnormal allocation into non-QE government securities into an abnormal allocation into newly issued and previously issued non-QE government securities:

$$\%\Delta Abnormal\ Non\text{-}QE\ Treasury\ Allocation_{jt} = \%\Delta Abnormal\ Non\text{-}QE\ New\ Treasury\ Allocation_{jt} + \%\Delta Abnormal\ Non\text{-}QE\ Old\ Treasury\ Allocation_{jt} \quad (7)$$

$$\%\Delta Abnormal\ Non\text{-}QE\ Agency\ Allocation_{jt} = \%\Delta Abnormal\ Non\text{-}QE\ New\ Agency\ Allocation_{jt} + \%\Delta Abnormal\ Non\text{-}QE\ Old\ Agency\ Allocation_{jt} \quad (8)$$

Our regression results suggest that any portfolio balance effect of Agency QE likely occurred outside of the mutual fund portfolios. Starting with pure funds, the coefficient on *% QE Agency* is 0.153 for allocations to previously issued non-QE Agency securities, and is -0.036 (statistically insignificant) for newly issued non-QE Agency securities. Some also went to newly issued Treasury securities (coefficient of 0.046), likely due to the liquidity of newly issued benchmark bonds. Consistent with this argument, funds increase their allocation to newly issued securities following fund flows. Previous research has shown that fund flows result in an increase in fund investment in liquid assets (Dubofsky 2010). The results for Agency securities are very similar for mixed funds. Altogether, this suggests that proceeds from QE-related Agency sales went mostly into previously issued non-QE Agency securities.

Likewise, for each dollar invested into Treasuries from QE-related Treasury sales, between one-half and two-thirds went to newly issued government securities (=0.081/(0.081+0.078) for pure funds). Mixed funds tilt their portfolio more towards newly issued government securities. The coefficient on *% QE* is 0.267 for allocations to newly issued non-QE Treasury securities, whereas it is 0.156 for previously issued non-QE Treasury securities.

3.2 How do mutual funds investors rebalance their portfolios around Federal Reserve QE purchases?

So far, we have analyzed the portfolio rebalancing that occurs inside mutual fund portfolios. It is also possible that the portfolio balance channel could be transmitted through the investors in mutual funds. Mutual fund investors, for example, could reduce their exposure to Treasury-only funds and increase their exposure to corporate-focused funds, and we would not see this portfolio rebalancing effect in the fund portfolio regressions we have examined so far. When the Federal Reserve purchases government bonds, for example, it increases their price; to generate yield, investors may substitute out of government bond funds into more corporate bond funds, which may provide a more attractive yield. This is more challenging to identify since, unlike mutual funds, we do not have information on the portfolios of investors in mutual funds. We can, however, explore how investor flows respond to funds that have a higher exposure to securities the Federal Reserve is purchasing. This can help us to see whether mutual fund investors are rebalancing away from QE securities. But it cannot identify where the money is going, since we cannot relate inflows into a corporate bond fund to outflows from a Treasury-focused fund. We can only test whether inflows into other funds are happening during QE periods. The following regression explores the effect of QE on fund flows:

$$Flow_{jt} = \alpha + \beta_1 \, \%SOMA_{jt-1} + \beta_2 \, \% \, QE_{jt-1} + \beta_3 \, Flow_{jt-1} + \beta_4 \, Return_{jt-1} + \gamma_i + \epsilon_t + \varepsilon_{it} \quad (9)$$

Given the inclusion of a lagged dependent variable, the above regression accounts for persistence in fund flows. As well, it controls for potential flow-performance sensitivity (e.g., Chevalier and Ellison 1997) with the *Return* variable, as well as for any time-specific or fund-specific fixed effects.

Investors do reduce their exposure to funds that are holding securities the Federal Reserve is buying in the current quarter (**Table 6, Panel A**). Across all funds, the coefficient on *% QE* is a statistically significant -0.086. This implies that a fund fully invested in securities the Federal Reserve was purchasing in the same quarter would experience additional outflows of almost 9%. This is above and beyond any effect of holding these securities in the fund's portfolio: the coefficient on *%SOMA* is much smaller at -0.026, implying that investors also redeem from funds when those funds had a higher exposure to government securities the previous quarter. The result should be more evident in pure funds, given that investors would not expect as much portfolio rebalancing to occur within these funds, so they would need to undertake the portfolio balance themselves. This is indeed true. The coefficient on *%QE* is more negative and is statistically significant in pure funds (-0.071), whereas it is not statistically significant in mixed funds. Pure funds include both pure corporate funds and pure government funds. For all the corporate funds, the *%QE* is close to zero, so this coefficient may be capturing a flow out of pure government funds into pure corporate funds, which would be consistent with portfolio rebalancing on the part of mutual fund investors. When examining only pure government funds, the effect is still statistically significant and negative but of a smaller magnitude compared with all pure funds combined. Therefore, some of the flow effect is due to non-government funds receiving inflows when government funds exposed to QE purchases are experiencing outflows.

To see the flows into different fund types more clearly, **Panel B** examines whether certain types of pure funds receive more inflows during QE periods than during non-QE periods:

$$\begin{aligned} Flow_{jt} = \alpha + \beta_1\, Flow_{jt-1} + \beta_2\, Return_{jt-1} + \beta_3\, Family\ Flow_{jt} \\ + \beta_4\, QE_t + \beta_5\, QE_t * Corporate\ Fund_j \\ + \beta_6\, QE_t * International\ Fund_j + \beta_7\, QE_t * Other\ Fund_j \\ + \gamma_i + \epsilon_t + \varepsilon_{it} \qquad (10) \end{aligned}$$

In this regression, *QE* is a dummy variable that is equal to one in the quarters when the Federal Reserve was making *QE* purchases (2008Q4–2010Q1; 2010Q4–2011Q2; 2012Q3–2013Q4). Given the inclusion of the interaction terms with the various pure-fund types (*Corporate Fund*, *International Fund* and *Other Fund*), the coefficient on the *QE* variable represents the change in flows experienced by government funds during QE quarters. The coefficients on the interaction terms represent the change in flows for the other fund types during QE quarters, relative to the change in flows for government funds. The regression also controls for the average fund flows experienced by other funds within the same fund family, measured by the variable *Family Flow*.

The results in **Panel B** support our earlier interpretation. In column (1), the coefficient on the interaction between *QE* and *Corporate Fund* is positive and statistically significant. This conveys that corporate funds received almost 3% of assets more in net flows during QE quarters, relative to the change in flows experienced by government funds. This difference is economically significant given that it suggests a difference of more than 10% of assets in investor flows on an annual basis. The effect is economically stronger for other funds that invest in securities such as ABS and Non-Agency MBS (though weaker statistically). International funds do not experience a statistically significant difference in flow behaviour during QE periods. These funds invest slightly more in US government bonds than do corporate or other funds and are also likely investing in government bonds from other economies undergoing QE, which could explain the absence of a measurable effect. There could be concern that these results are simply due to a time trend in inflows. For instance, corporate bond funds have increased significantly in size since 2010, and the loading on the QE interactions could simply be capturing a trend of more investment in corporate bonds during this period. To address this concern, column (2) includes a *Post-2010* dummy variable that is equal to one in every quarter from 2010Q1 and after, as well as interactions with the dummy variables representing different types of funds. If a trend in inflows was indeed the cause, we should witness a reduction in the coefficients on the interactions with the QE variable, and sizeable coefficients on the *Post-2010* interaction variables. This is not the case. The coefficients on the *QE* interactions are unchanged (albeit with slightly less significance, given the correlation between the *QE* and *Post-2010* variables), and the coefficients on the *Post-2010* interaction terms are mostly insignificant. In columns (3) and (4), *Family Flow* is included as an additional control variable. Although family flows affect fund flows, the inclusion of this variable has little impact on our variables of interest. The variable suggests that a fund should expect to receive net flows equivalent to about 20% of the average flows other funds in the family are experiencing. We exclude time dummy variables in columns (5) and (6) to see the impact that QE has on government funds (in the specifications with time dummy variables, the QE coefficient is swept away by the time dummies). In this specification, the effect of family flows increases, as it replaces some of the impact of the time dummies, which were capturing the average flows across all funds. This suggests that a component of family flows is common across all fund families. The coefficient on the *QE* variable is negative and indicates that government funds received just over 1% less flows in QE quarters than they did on other quarters. This suggests that the combined effect on corporate funds was about 1% more flows than in other quarters (-0.014 + 0.027), which mirrors the change in government flows.

4. Robustness tests

The fund-level analysis in this paper shows that mutual funds sell the securities that the Federal Reserve was purchasing. However, it is possible that the effect we measure is not an accurate portrayal of the economic impact of QE if the effect we measure is driven by smaller funds in the sample. Therefore, as a robustness check, we supplement our analysis by examining whether mutual funds (in the aggregate) sold the individual SOMA securities the Federal Reserve was buying in the same quarter the Federal Reserve was purchasing those securities. By confirming the results at a security level, we can gain more confidence in the results we presented earlier at a fund level.

The dependent variable we are interested in is the aggregate percentage change in bond fund holdings of a given security. Recall that we earlier defined *ΔALLOCATION* as the dollar change in allocation of a given bond. The aggregate quarterly percentage change is then simply the sum of all these allocation changes across funds, scaled by the market value of that bond held by all funds in the previous period:

$$\%\Delta SOMA_{it} = \Sigma_j \, \Delta ALLOCATION_{ijt} \; / \; \Sigma_j MARKET\ VALUE_{ijt-1} \qquad (11)$$

We need to control for the effect of investor flows on the aggregate purchases and sales of securities by mutual funds, similar to what has been done in previous mutual fund research. Coval and Stafford (2007) measure selling pressure at an individual stock level by relating flows in the funds holding that stock to the volume of trade in the stock and find that this relates to abnormal negative stock returns. Manconi, Massa and Yasuda (2012) examine the effect of securitized bond holdings on changes in corporate bond spreads and trading volume in a similar vein. For each corporate bond, they measure the weighted average fraction of securitized bonds held by the mutual funds that also hold the corporate bond, using the par amount of the corporate bond held by each fund as weights. At a security level, Ben-Rephael (2014) analyzes how changes in the aggregate mutual fund holdings of a stock during crisis periods are influenced by the stock's liquidity. Similar to these studies, we measure the exposure of a security to fund flows by defining the following security-level variables. For each bond, we weight investor flows by the size of the position held by each fund holding the bond. More formally, the weights are

$$w_{ijt-1} = \text{MARKET VALUE}_{ijt-1} \; / \; \Sigma_j \text{MARKETVALUE}_{ijt-1} \qquad (12)$$

Karolyi and McLaren (2016) look at the impact of changes in flow-implied fund allocation around the Federal Reserve's tapering announcement and its impact on emerging- market stocks. Jotikasthira, Lundblad and Ramadorai (2012) construct a measure of flow-induced trading of fund allocations to emerging markets. This "Flow-Implied Fund Allocation," or *FIFA*, measures the change in aggregate fund allocation an emerging market would be expected to experience as a result of flows from the funds invested in that market. All else equal, if a security is held by funds that experience a high amount of inflows, we should expect aggregate mutual fund holdings of that security to increase. We define this variable in a similar manner:

$$FIFA_{it} = \Sigma_j \left(w_{ijt-1} * flow_{jt} \right) \tag{13}$$

To test for the impact of QE on mutual fund holdings, we run a panel regression with both security and time fixed effects. The time fixed effects should control for any market-wide changes in fund allocations to government and Agency securities, while the security fixed effects should account for any unobserved effect influencing allocation changes to each security over the sample period.

$$\%\Delta SOMA_{it} = \alpha + \beta_1 FIFA_{it} + \beta_2\, QE_{\,it} + \gamma_i + \epsilon_t + \varepsilon_{it} \tag{14}$$

Our independent variable of interest is a dummy variable, *QE*, which is equal to one in quarters when the Federal Reserve is purchasing that security. If mutual funds do sell securities that the Federal Reserve is purchasing, we should expect a negative coefficient on this variable.

In our regressions results (**Table 7**), we do indeed find evidence corroborating our earlier finding that funds are selling assets to the Federal Reserve. For Agency securities, the coefficient on *QE* is equal to -0.22 and is statistically significant, indicating a 22% reduction in fund holdings of Agency securities when they are being purchased by the Federal Reserve. When the Fed is buying a given Treasury, funds decrease their holdings of that specific Treasury by around 10%. This is roughly in line with the proportion of outstanding that the Federal Reserve purchased when it buys Treasuries (recall that we conditioned on the Federal Reserve purchasing at least 5% of outstanding to classify a Fed treasury purchase as QE).

Our analysis so far looks at the transaction effect of Federal Reserve purchases; however, it is possible announcement effects could also be present. Several studies have looked at the effect of QE around Federal Reserve announcements of purchases (e.g., D'Amico and King 2013). To test for these announcement effects, we include one lead and one lag of our dummy variable of interest, *QE*. If there is an announcement effect, we would expect to see a similar, negative coefficient on the lead of this variable. On the other hand, there could also be a lagged effect if other participants, such as banks, sell a security when it is being bought by the Federal Reserve, and then later replace it in their portfolio by buying it from mutual funds. The evidence suggests that this is not the case for Agency securities. The coefficient on the lead of the dummy variable is positive and about a quarter of the magnitude of the value of the concurrent coefficient. The positive coefficient is consistent with the fact that Federal Reserve QE purchases were concentrated on newly issued MBS (Chakraborty, Goldstein and MacKinlay 2016). After purchasing a newly issued MBS, a mutual fund may then sell it into QE the following quarter. There is some evidence of an announcement effect for Treasuries, given the negative coefficient on the lead of the *QE* dummy (coeff. = -0.037, t-stat = 1.90). It is not surprising that this effect is weaker, given that the Federal Reserve did not announce the particular securities it was purchasing when it announced its quantitative easing programs.

This security-level analysis is also robust to a different measure of mutual fund holdings of that security. The measure we employ in the security-level analysis in this paper is the percentage change in the aggregate holdings of that security. To investigate whether this behaviour is widespread across many funds, we estimate the same regressions with a new measure, which is the percentage change in the number of individual funds that hold the security. **Table 8** shows that the results using this alternative measure are very similar to the results using the original measure.

In our analysis, we apply a threshold to identify Federal Reserve Treasury QE purchases, and this could result in an understatement of the amount of QE purchases. We require that the Federal Reserve purchase at least 5% of the outstanding par value of a Treasury bond in a given quarter to be classified as QE. The purpose of this threshold is to focus on effects that are likely to have a measurable impact on mutual fund behaviour. If only, say, 0.5% of a bond is purchased in a given quarter, it will result in smaller changes to mutual fund portfolios than a purchase of 10% of the outstanding par value of a bond.

To determine whether our 5% threshold misses an economically significant amount of QE purchases, **Figure 3** plots the aggregate quarterly amount of Treasury QE purchases using different thresholds as well as the quarterly change in the Federal Reserve's SOMA holdings of Treasuries. During QE1, QE2 and the latter part of QE3, using any threshold understates the quarterly change in the SOMA portfolio. This is because we also do not classify a purchase as QE if Treasury issuance exceeds Federal Reserve purchases of a given bond in a given quarter. Although we understate QE purchases by $100 billion during some quarters of QE2, the QE purchases we do not consider do not result in a reduction in the net supply of that particular bond (e.g., public holdings outside of the consolidated balance sheet of the Treasury and Federal Reserve), and hence should not result in incentives for mutual funds to sell that bond. Post-QE2, we can see the results of Operation Twist. The net change in the SOMA portfolio is close to zero, yet all of the thresholds considered show that the Federal Reserve was purchasing bonds in these quarters. The figure also illustrates that using a threshold of 5% results in a small understatement of QE purchases relative to the three other thresholds we consider (0%, 1% and 3%).

However, the effect of QE on mutual fund portfolio rebalancing is similar, but slightly smaller, if we identify Treasury QE purchases using a 1% threshold instead of a 5% threshold (**Table 9**). Compared to Table 3, the coefficient on *% QE* is -0.103 for the abnormal allocation to SOMA QE bonds in pure funds using the 1% threshold, relative to -0.169 when using the 5% threshold. Given that the Federal Reserve was purchasing a smaller amount of the outstanding stock of bonds when defined using this new threshold, this result is unsurprising. Like the earlier results, the same coefficient for SOMA non-QE bonds is of the same magnitude but of the opposite sign, maintaining the result that most of the QE rebalancing went into other government securities. For mixed funds, the coefficients using the 1% threshold are almost the same as the coefficients using the 5% threshold. Therefore, the results are not sensitive to the choice of threshold.

The reduced allocation to securities the Federal Reserve is purchasing in the current quarter and the increased allocation to non-QE government securities may be the result of passive rebalancing effects (i.e., following changes in the index). QE purchases and Treasury issuance both affect the benchmark indexes against which mutual funds track their performance. A Federal Reserve purchase removes a security from the public float, and this, in turn, reduces the weight of that bond in bond benchmarks. Likewise, Treasury issuance of a security also increases the public float of the security and hence its weight in the benchmark indexes. Because mutual funds do not want to deviate too much from their benchmarks, they have incentives to sell the QE securities the Federal Reserve is purchasing and to buy the government securities the Treasury is issuing. To see whether our results are present in active funds, we perform our test on a subset of more actively managed funds. We look at both non-index funds as well as funds that have a higher *Active Share* (Cremers and Petajisto 2009), calculated at a quarterly frequency. *Active Share* measures how similar a fund's portfolio is to that of a benchmark and ranges from 0 to 1 with a lower *Active Share* indicating more passive management:[12]

$$Active\ Share_{jt} = \tfrac{1}{2} \Sigma_i \left| \mathrm{w}_{i,\,j} - \mathrm{w}_{i,\,index} \right| \qquad (15)$$

Our results are similar in a subset of more active funds (**Table 10)**. The first column redisplays the results from a regression involving all index funds, while the second column examines only non-index funds. In the third column, we focus on only those funds with an *Active Share* greater than 0.6. Cremers and Petajisto (2009) suggest that equity funds with an *Active Share* below 0.6 are closet indexers. Since only a small fraction of bond funds have an *Active Share* below 0.6, we also consider a higher threshold of 0.9 for evaluating the most active funds. The coefficient on *SOMA QE Exposure* is virtually unchanged across the different subsets of funds.

5. Concluding remarks

Most research regarding the portfolio balance channel focuses on the behaviour of government bond prices and other asset prices around QE announcements. In this paper, we depart from this literature by analyzing directly how QE alters the quantities of individual securities held by mutual funds.

We find that mutual funds sell the specific securities in the same quarter that the Federal Reserve is purchasing them. In particular, mutual funds with broader mandates sold more QE-purchased securities, suggesting that portfolio adjustments are occurring in mutual funds with more flexible mandates. Our research suggests that mutual funds mostly rebalance into other government securities that the Federal Reserve did not buy that quarter. A large portion of this rebalancing went into newly issued government securities. QE purchases reduce the weight of the purchased bond in fund benchmark portfolios, which may create incentives for funds to sell the bond if they do not want to increase their tracking error against their benchmark index. Likewise, funds may have incentive to purchase newly issued government bonds, as these become included in their benchmark index. For every $100 in QE bonds sold, mutual funds replenished their portfolios with about $50 to $60 of newly issued government bonds. Our results are consistent

[12] Since we do not have the holdings of the major bond benchmarks, we use the holdings of the bond index funds that we have in our sample. As do Cremers and Petajisto (2009), we measure *Active Share* against all of the potential benchmarks in our sample and take the minimum so that we are calculating *Active Share* relative to a fund's closest benchmark index.

with these benchmark effects on fund portfolios. This suggests that the portfolio balance channel impacts mutual fund behaviour through changes in their benchmark index.

Our results suggest that Federal Reserve quantitative easing initiated important portfolio balance effects in mutual fund portfolios. Contrary to the common wisdom about the portfolio balance channel, most of the proceeds from within-fund rebalancing purchased other government and Agency securities, rather than corporate bonds. We provide evidence that fund investors, in contrast, redeemed from government-focused funds and invested in corporate bond funds, suggesting that portfolio rebalancing into corporate bonds occurred across funds, rather than within funds. The overall effect of this is quite significant, as corporate bond funds received an additional 3% of assets in inflows in each QE quarter (in dollar terms, \$50 to \$60 billion over the whole QE period), relative to government bond funds.

Appendix A. Variable descriptions.

FIFA	This variable measures the concurrent weighted average flows of funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio.
SOMA Indicator	This dummy variable takes the value of 1 if the security was ever held in the Federal Reserve's SOMA portfolio during the sample period.
Fed buying	This dummy variable takes the value of 1 if the security was purchased by the Federal Reserve during the current quarter.
% SOMA	This variable measures the concurrent weighted average portfolio allocation to SOMA securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio.
SOMA Government Exposure	This variable measures the concurrent weighted average portfolio allocation to SOMA Treasury securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio.
SOMA Agency Exposure	This variable measures the concurrent weighted average portfolio allocation to SOMA Agency securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio.
SOMA Short Maturity Exposure	This variable measures the concurrent weighted average portfolio allocation to SOMA short maturity securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio. Short maturity securities are defined as those with a maturity less than 10 years.
SOMA Long Maturity Exposure	This variable measures the concurrent weighted average portfolio allocation to SOMA long maturity securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio. Long maturity securities are defined as those with a maturity greater than or equal to 10 years.
% QE	This variable measures the concurrent weighted average portfolio allocation to SOMA securities that the Federal Reserve is buying in the current quarter for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio. SOMA Government Fed Purchase Exposure, SOMA Agency Fed Purchase Exposure, SOMA Short Maturity Fed Purchase Exposure, and SOMA Long Maturity Fed Purchase Exposure are similarly defined.
Similar Maturity Exposure $_t$	Similar Maturity Exposure ranges between zero and one and measures the extent to which the security in question is within the interquartile range of the maturity of the funds holding that security. Weights are determined based on the market value of the security held in each fund's portfolio.
Δ Bond	Measures the quarterly percentage change in mutual fund aggregate holdings to a CUSIP.
Maturity	Provides the maturity of the security in years. Securities with a maturity greater than 50 years are assigned missing values.
Ln (# of funds holding)	Measures the logarithm of the number of funds holding the security in question in the given quarter.
Mean Issuer Δ Holdings	Measures the average quarterly percentage change in mutual fund aggregate holdings to all the CUSIPs of the security's issuer.

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Table 1
Summary Statistics
This table reports summary statistics for the entire sample (pooled observations). Variable definitions are provided in Appendix A.

Panel A: Fund-level Data

	N	Average Fund Size ($ B)	% in Corporate Bonds	% in Agencies	% in Government	% in International	% in Other
Pure Corporate	192	1.14	0.73	.025	.015	.16	.08
Pure Government	170	1.43	.059	.45	.32	.05	.12
Pure International	65	0.29	.045	.003	.03	.90	.03
Pure Other	9	.51	.24	.006	.001	.07	.68
Mixed	460	2.0	.27	.19	.12	.15	.27
Total	896	1.58	.28	.20	.13	.16	.23

Panel B: Security-level Data

	N	% in SOMA	# of Funds Holding CUSIP	Aggregate Position Size ($M)	Flow Exposure	SOMA Exposure	Maturity (Years)	Yield	Spread	HY %
ABS	13,077	0	2.7	9.4	-.001	.15	15.6	.052	.022	.20
Agency	199,500	.076	1.3	4.5	-.009	.23	18.4	.066	.031	.25
Cash	1,099	0	1.0	33.1	.040	.18	2. 4	.037	.024	.16
Corporate Bonds	21,633	0	11.3	41.6	.009	.13	7.5	.061	.036	.35
Government Bonds	1,360	.42	14.0	545.1	.008	.30	5.1	.018	.000	.01
International Bonds	23,267	0	4. 4	21.1	.029	.09	8.1	.056	.035	.29
Municipal Bonds	48,456	0	.5	1.6	-.005	.06	12.2	.041	.014	.08
Non-Agency MBS	17,348	0	2.34	7.8	.008	.15	24.8	.074	.039	.28
Other	2,426	0	2.4	27.7	.010	.06	13.2	.057	.029	.28
Total	328,166	.048	2.2	10.6	-.003	.20	16.1	.062	.030	.24

Table 2

Fund Allocation Changes by Quintile of Exposure to Quantitative Easing

We classify funds based on their exposure to QE purchases. Each quarter, we measure the proportion of the fund's market value that is invested in securities that the Federal Reserve is purchasing. We then divide those funds that have some exposure to QE purchases into quintiles, with funds in the first quintile having the lowest exposure and funds in the fifth quintile having the highest exposure. We measure this allocation change as the dollar change in the fund allocation, as a percentage of the end of the prior quarter's fund assets, less the fund allocation change that could be expected to occur based on fund flows (i.e., the percentage of fund flows multiplied by the percentage of the fund's assets invested in the asset class in the prior quarter).

Panel A: All Funds

Quintile	% Portfolio in QE Securities	% Portfolio in SOMA Securities	Fund AUM ($B)	Fund flows	Corporate Allocation Δ	Int'l Allocation Δ	Non-QE Gov't Allocation Δ	QE Gov't Allocation Δ	Cash Allocation Δ
1	0.005	0.150	3.83	0.021	-0.001	0.002	0.001	0.001	-0.000
2	0.020	0.217	3.06	0.022	-0.001	0.002	0.003	-0.002	-0.000
3	0.040	0.281	3.83	0.019	0.002	0.003	0.002	-0.005	-0.001
4	0.072	0.360	4.82	0.021	0.002	0.003	0.006	-0.010	0.000
5	0.154	0.471	3.75	0.013	0.003	0.001	0.023	-0.029	0.000
Overall	0.058	0.295	3.86	0.020	0.001	0.002	0.007	-0.009	0.000

Panel B: Mixed Funds

Quintile	% Portfolio in QE Securities	% Portfolio in SOMA Securities	Fund AUM ($B)	Fund flows	Corporate Allocation Δ	Int'l Allocation Δ	Non-QE Gov't Allocation Δ	QE Gov't Allocation Δ	Cash Allocation Δ
1	0.006	0.140	4.12	0.021	-0.001	0.001	0.002	0.001	0.000
2	0.020	0.193	3.42	0.027	-0.002	0.002	0.005	-0.002	-0.001
3	0.040	0.245	4.18	0.021	0.002	0.003	0.002	-0.005	-0.001
4	0.073	0.327	5.86	0.025	0.003	0.003	0.006	-0.012	0.000
5	0.131	0.387	5.63	0.027	0.005	0.003	0.026	-0.035	-0.000
Overall	0.050	0.253	4.59	0.024	0.001	0.002	0.007	-0.009	-0.000

Table 2 (continued)

Panel C: Pure Funds

Quintile	% Portfolio in QE Securities	% Portfolio in SOMA Securities	Fund AUM ($B)	Fund flows	Corporate Allocation Δ	Int'l Allocation Δ	Non-QE Gov't Allocation Δ	QE Gov't Allocation Δ	Cash Allocation Δ
1	0.005	0.184	3.35	0.022	-0.001	0.003	0.000	0.001	-0.001
2	0.019	0.317	2.17	0.011	0.001	0.001	-0.001	-0.001	-0.000
3	0.042	0.402	2.94	0.016	0.002	0.002	0.001	-0.002	-0.001
4	0.072	0.485	2.25	0.013	0.000	0.001	0.006	-0.006	-0.001
5	0.178	0.573	1.71	-0.002	0.001	-0.000	0.018	-0.021	0.001
Overall	0.074	0.404	2.43	0.011	0.001	0.001	0.006	-0.007	-0.000

Table 3

Fixed Effects Regressions of Changes in Abnormal Fund Allocation

The dependent variable in these fixed effect regressions are quarterly changes in the duration of individual mutual funds. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

Panel A: Pure Funds

	Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal QE Allocation	Abnormal Non-QE Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
% SOMA $_{t-1}$	0.023	0.008	-0.005	-0.056	0.007	0.023
	(1.99)*	(2.53)**	(0.64)	(3.02)***	(1.51)	(3.09)***
% QE $_{t-1}$	0.006	-0.014	-0.162	0.165	0.007	-0.002
	(0.89)	(3.84)***	(7.25)***	(5.80)***	(1.09)	(0.36)
Fund flows $_{t-1}$	-0.022	-0.012	-0.006	0.034	0.025	-0.020
	(3.31)***	(2.90)***	(1.33)	(3.80)***	(4.43)***	(3.44)***
Fund return $_{t-1}$	0.042	0.011	-0.025	-0.035	-0.016	0.023
	(2.13)**	(0.71)	(1.55)	(1.36)	(1.70)*	(1.20)
R^2	0.08	0.09	0.25	0.11	0.11	0.07
N	7,964	7,964	7,964	7,964	7,964	7,964

Panel B: Mixed Funds

	Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal QE Allocation	Abnormal Non-QE Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
% SOMA $_{t-1}$	0.074	0.019	-0.000	-0.136	0.011	0.032
	(7.84)***	(3.78)***	(0.02)	(10.48)***	(2.57)**	(4.19)***
% QE $_{t-1}$	0.025	-0.002	-0.313	0.295	-0.010	0.004
	(2.61)**	(0.22)	(9.77)***	(7.19)***	(1.70)*	(0.30)
Fund flows $_{t-1}$	-0.085	-0.033	-0.006	0.148	0.030	-0.054
	(9.87)***	(7.73)***	(2.05)**	(9.91)***	(4.44)***	(7.78)***
Fund return $_{t-1}$	0.081	0.011	-0.006	-0.120	-0.020	0.055
	(1.43)	(0.35)	(0.23)	(1.00)	(0.89)	(1.07)
R^2	0.16	0.08	0.41	0.19	0.08	0.11
N	8,233	8,233	8,233	8,233	8,233	8,233

Table 4

Fixed Effects Regressions of Changes in Abnormal Fund Allocation by Agency vs. Treasury Securities

The dependent variable in these fixed effect regressions are quarterly changes in the duration of individual mutual funds. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

Panel A: Pure Funds

	Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal QE Agency Allocation	Abnormal QE Treasury Allocation	Abnormal Non-QE Agency Allocation	Abnormal Non-QE Treasury Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
% SOMA Agency $_{t-1}$	0.012	0.001	0.001	0.001	-0.175	0.113	0.036	0.011
	(0.99)	(0.24)	(0.08)	(0.14)	(2.91)***	(1.79)*	(1.50)	(0.65)
% QE Agency $_{t-1}$	0.007	-0.011	-0.162	0.011	0.128	0.017	-0.002	0.012
	(0.72)	(2.14)**	(3.56)***	(2.46)**	(2.49)**	(0.95)	(0.25)	(0.78)
% SOMA Treasury $_{t-1}$	0.012	-0.001	-0.002	-0.018	0.157	-0.189	0.008	0.032
	(1.26)	(0.07)	(0.24)	(1.64)	(3.73)***	(4.01)***	(1.46)	(1.68)
% QE Treasury $_{t-1}$	0.013	-0.023	-0.007	-0.168	0.010	0.174	0.008	-0.008
	(1.44)	(2.12)**	(1.74)*	(5.63)***	(0.42)	(4.36)***	(1.34)	(1.01)
% SOMA Agency $_{t-2}$	0.011	0.006	0.007	0.002	0.121	-0.117	-0.034	0.004
	(0.74)	(0.83)	(0.33)	(0.39)	(1.86)*	(1.74)*	(1.54)	(0.29)
% QE Agency $_{t-2}$	-0.007	0.003	-0.009	-0.015	-0.026	0.051	0.014	-0.011
	(0.65)	(0.53)	(0.25)	(1.91)*	(0.51)	(1.18)	(0.90)	(0.76)
% SOMA Treasury $_{t-2}$	0.015	0.011	0.001	0.009	-0.044	0.017	-0.002	-0.006
	(1.08)	(1.14)	(0.09)	(0.99)	(1.38)	(0.41)	(0.29)	(0.43)
% QE Treasury $_{t-2}$	-0.004	0.012	0.002	0.019	-0.001	-0.036	-0.005	0.012
	(0.39)	(1.04)	(0.28)	(0.90)	(0.04)	(1.25)	(0.95)	(1.34)
Fund flows $_{t-1}$	-0.022	-0.012	-0.001	-0.005	-0.007	0.041	0.025	-0.020
	(3.29)***	(2.89)***	(0.34)	(2.60)**	(0.52)	(3.89)***	(4.47)***	(3.44)***
Fund return $_{t-1}$	0.042	0.013	-0.028	0.003	0.024	-0.060	-0.017	0.024
	(2.09)**	(0.84)	(2.00)*	(0.43)	(1.08)	(2.19)**	(1.77)*	(1.23)
R^2	0.08	0.09	0.20	0.31	0.09	0.14	0.11	0.07
N	7,964	7,964	7,964	7,964	7,964	7,964	7,964	7,964

Table 4 (continued)

Panel B: Mixed Funds

	Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal QE Agency Allocation	Abnormal QE Treasury Allocation	Abnormal Non-QE Agency Allocation	Abnormal Non-QE Treasury Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
% SOMA Agency $_{t-1}$	0.061	-0.009	-0.012	0.009	-0.101	0.062	-0.020	0.009
	(2.75)***	(0.73)	(0.51)	(1.25)	(2.94)***	(1.48)	(1.31)	(0.51)
% QE Agency $_{t-1}$	0.012	0.009	-0.240	-0.009	0.118	0.119	0.004	-0.013
	(0.64)	(0.91)	(10.16)***	(1.12)	(1.95)*	(2.62)**	(0.30)	(0.45)
% SOMA Treasury $_{t-1}$	0.048	0.015	0.011	0.003	0.122	-0.239	0.028	0.013
	(4.07)***	(1.53)	(2.69)**	(0.45)	(4.92)***	(7.45)***	(2.90)***	(1.06)
% QE Treasury $_{t-1}$	0.035	-0.036	0.022	-0.428	0.032	0.431	-0.024	-0.031
	(2.13)**	(1.85)*	(1.50)	(7.48)***	(0.67)	(6.66)***	(1.97)*	(1.76)*
% SOMA Agency $_{t-2}$	0.002	0.019	-0.015	0.003	-0.019	-0.033	0.018	0.025
	(0.11)	(1.40)	(0.77)	(0.22)	(0.42)	(0.70)	(1.44)	(1.07)
% QE Agency $_{t-2}$	0.014	0.012	0.014	-0.003	-0.024	-0.063	-0.010	0.060
	(0.67)	(1.26)	(0.72)	(0.39)	(0.47)	(1.21)	(0.70)	(2.26)**
% SOMA Treasury $_{t-2}$	0.039	0.009	-0.011	-0.001	-0.042	-0.000	-0.017	0.024
	(3.50)***	(1.01)	(2.41)**	(0.26)	(1.89)*	(0.01)	(1.86)*	(2.55)**
% QE Treasury $_{t-2}$	0.008	0.036	-0.006	-0.010	-0.068	-0.027	0.039	0.027
	(0.55)	(2.36)**	(0.28)	(0.48)	(1.39)	(0.68)	(2.52)**	(1.10)
Fund flows $_{t-1}$	-0.085	-0.033	-0.002	-0.004	0.065	0.083	0.030	-0.054
	(9.89)***	(7.70)***	(1.07)	(2.46)**	(4.48)***	(9.89)***	(4.47)***	(7.83)***
Fund return $_{t-1}$	0.085	0.016	-0.003	-0.012	-0.163	0.029	-0.015	0.062
	(1.51)	(0.55)	(0.11)	(0.45)	(2.52)**	(0.55)	(0.64)	(1.27)
R^2	0.16	0.08	0.33	0.49	0.12	0.20	0.08	0.12
N	8,233	8,233	8,233	8,233	8,233	8,233	8,233	8,233

Table 5

Fixed Effects Regressions of Changes in Abnormal Fund Allocations

The dependent variable in these fixed effect regressions are quarterly changes in the abnormal non-SOMA allocation of individual mutual funds. New allocations are securities that were not held by any mutual fund in our sample prior to the preceding quarter. Old securities include all other securities. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

Panel A: Pure Funds

	Agency Securities		**Treasuries**	
	Abnormal Non-QE Old Allocation	**Abnormal Non-QE New Allocation**	**Abnormal Non-QE Old Allocation**	**Abnormal Non-QE New Allocation**
% SOMA Agency $_{t-1}$	-0.131	0.054	0.018	0.001
	(4.70)***	(2.00)*	(1.07)	(0.07)
% QE Agency $_{t-1}$	0.153	-0.036	0.000	0.046
	(3.17)***	(0.54)	(0.01)	(2.91)***
% SOMA Treasury $_{t-1}$	0.066	0.058	-0.156	-0.022
	(2.87)***	(2.22)**	(7.56)***	(1.57)
% QE Treasury $_{t-1}$	-0.001	0.010	0.078	0.081
	(0.04)	(0.80)	(2.38)**	(2.25)**
Fund flows $_{t-1}$	-0.055	0.049	0.009	0.031
	(3.41)***	(3.35)***	(0.70)	(2.76)***
Fund return $_{t-1}$	-0.006	0.027	-0.080	0.025
	(0.18)	(0.69)	(1.64)	(0.69)
R^2	0.27	0.31	0.23	0.32
N	7,964	7,964	7,964	7,964

Table 5 (continued)

Panel B: Mixed Funds

	Agency Securities		Treasuries	
	Abnormal Non-QE Old Allocation	**Abnormal Non-QE New Allocation**	**Abnormal Non-QE Old Allocation**	**Abnormal Non-QE New Allocation**
% SOMA Agency $_{t-1}$	-0.159	0.041	0.020	0.014
	(7.93)***	(2.00)*	(1.16)	(0.77)
% QE Agency $_{t-1}$	0.136	-0.034	-0.025	0.108
	(3.84)***	(1.22)	(1.01)	(2.56)**
% SOMA Treasury $_{t-1}$	0.058	0.030	-0.200	-0.042
	(5.18)***	(3.81)***	(14.16)***	(2.37)**
% QE Treasury $_{t-1}$	0.016	-0.007	0.156	0.267
	(0.53)	(0.33)	(5.10)***	(3.94)***
Fund flows $_{t-1}$	0.010	0.055	0.030	0.053
	(0.90)	(4.57)***	(4.31)***	(4.99)***
Fund return $_{t-1}$	-0.078	-0.074	-0.041	0.080
	(1.72)*	(1.88)*	(0.89)	(1.83)*
R^2	0.19	0.19	0.22	0.23
N	8,233	8,233	8,233	8,233

Table 6
Fixed Effects Regressions of Individual Fund Flows
The dependent variable in these fixed effect regressions are quarterly mutual fund net flows (as a percentage of the previous quarter's assets under management). Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

Panel A

	All Funds	**Passive Funds**	**Active Funds**	**Pure Funds**	**Pure Government Funds**	**Mixed Funds**
% SOMA $_{t-1}$	-0.025	-0.040	-0.026	-0.004	0.006	-0.049
	(1.85)*	(0.71)	(1.85)*	(0.20)	(0.33)	(2.36)**
% QE $_{t-1}$	-0.091	-0.020	-0.099	-0.128	-0.072	-0.029
	(2.40)**	(0.29)	(2.35)**	(2.65)**	(1.96)*	(0.61)
Fund flows $_{t-1}$	0.145	0.179	0.141	0.112	0.073	0.170
	(7.29)***	(3.65)***	(7.14)***	(4.71)***	(2.24)**	(7.05)***
Fund return $_{t-1}$	0.199	0.788	0.161	0.229	0.419	0.197
	(1.17)	(4.81)***	(0.91)	(1.18)	(1.76)*	(1.32)
R^2	0.22	0.36	0.21	0.23	0.23	0.22
N	15,235	962	14,270	7,422	3,568	7,813

Table 6 (continued)

Panel B

	(1)	(2)	(3)	(4)	(5)	(6)
Fund flows $_{t-1}$	0.112	0.112	0.109	0.109	0.129	0.125
	(4.71)***	(3.99)***	(4.55)***	(4.56)***	(4.92)***	(4.85)***
Fund return $_{t-1}$	0.205	0.202	0.202	0.200	0.130	0.146
	(0.80)	(0.34)	(1.00)	(6.91)***	(0.92)	(0.99)
Family flows $_t$			0.196	0.195	0.301	0.303
			(5.67)***	(5.66)***	(7.35)***	(7.25)***
QE					-0.014	-0.013
					(1.70)*	(1.61)
QE * Corporate Fund	0.028	0.028	0.029	0.029	0.027	0.027
	(2.29)**	(1.89)*	(2.36)**	(2.19)**	(2.16)**	(2.03)*
QE * International Fund	0.020	0.020	0.020	0.020	0.016	0.015
	(1.59)	(1.40)	(1.72)*	(1.52)	(1.34)	(1.18)
QE * Other Fund	0.049	0.049	0.052	0.052	0.050	0.049
	(1.78)*	(1.75)*	(1.81)*	(1.79)*	(1.75)*	(1.71)*
Post-2010						-0.013
						(1.51)
Post-2010 * Corporate Fund		0.001		0.001		0.004
		(0.07)		(0.08)		(0.21)
Post-2010 * International Fund		0.002		0.006		0.011
		(0.08)		(0.32)		(0.62)
Post-2010 * Other Fund		0.018		0.010		0.004
		(2.97)***		(1.56)		(0.39)
R^2	0.23	0.23	0.24	0.24	0.20	0.21
N	7,422	7,422	6,956	6,956	6,956	6,956

Table 7
Fixed Effect Regressions Describing Changes in Fund Holdings of SOMA Securities
The dependent variable in these fixed effect regressions are percentage quarterly changes in mutual fund holdings of the security. The first three columns examine changes in fund holdings of Agency securities at a CUSIP level, and the three rightmost columns examine changes in fund holdings of government securities at a CUSIP level. All variables are described in Appendix A. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

	Agencies			**Government**		
			(> 5 years)			**(> 5 years)**
$FIFA_t$	0.683	0.684	0.688	0.627	0.626	0.739
	(98.36)***	(98.48)***	(99.37)***	(9.23)***	(9.22)***	(11.99)***
SOMA Indicator * QE_t	-0.222	-0.222	-0.235	-0.106	-0.103	-0.095
	(44.47)***	(45.25)***	(46.38)***	(6.06)***	(5.84)***	(5.72)***
SOMA Indicator * QE_{t+1}		0.061			-0.037	
		(14.10)***			(1.90)*	
SOMA Indicator * QE_{t-1}		0.017			0.022	
		(4.10)***			(1.47)	
Constant	-0.283	-0.284	-0.277	-0.236	-0.237	-0.068
	(64.77)***	(65.09)***	(63.42)***	(11.80)***	(11.85)***	(3.06)***
R^2	0.24	0.24	0.25	0.07	0.07	0.11
N	104,177	104,177	101,237	7,723	7,723	3,154

Table 8

Fixed Effect Regressions Describing Changes in Fund Holdings of SOMA Securities – Robustness

The dependent variable in these fixed effect regressions are the percentage change in the number of individual funds that hold the security and Net Purchases, which we calculate as the aggregate dollar change in fund allocations to that security, scaled by our sample maximum of the aggregate dollar allocation to that security. The first two columns examine changes in fund holdings of Agency securities at a CUSIP level, and the two rightmost columns examine changes in fund holdings of government securities at a CUSIP level. All variables are described in Appendix A. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

	Agencies		**Government**	
	%Δ # Funds	**Net purchases**	**%Δ # Funds**	**Net purchases**
$FIFA_t$	0.489	0.379	0.096	0.246
	(7.58)***	(49.31)***	(0.57)	(5.92)***
SOMA Indicator * QE_t	-0.208	-0.163	-0.068	-0.087
	(6.44)***	(37.04)***	(4.98)***	(6.81)***
Constant	-0.340	-0.120	-0.156	-0.068
	(8.68)***	(32.13)***	(6.07)***	(7.15)***
R^2	0.00	0.11	0.03	0.03
N	107,205	107,193	8,071	8,071

Table 9

Fixed Effects Regressions of Changes in Abnormal Fund Allocation – Robustness to Threshold

The dependent variable in these fixed effect regressions are quarterly changes in the allocation of individual mutual funds to specific asset classes, beyond the allocations that would be expected based on their flows. In this table, a Federal Reserve Treasury purchase is classified as a QE purchase if the Federal Reserve purchases at least 1% of the outstanding par value of a given bond in a given quarter (as opposed to a 5% threshold in our main analysis). Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

Panel A: Pure Funds

	Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal QE Allocation	Abnormal Non-QE Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
% SOMA $_{t-1}$	0.024	0.008	-0.011	-0.051	0.007	0.022
	(2.21)**	(2.37)**	(1.04)	(2.71)**	(1.60)	(3.07)***
% QE $_{t-1}$	-0.001	-0.008	-0.103	0.107	0.006	-0.000
	(0.24)	(3.58)***	(6.22)***	(5.42)***	(2.03)*	(0.10)
Fund flows $_{t-1}$	-0.029	-0.013	-0.011	0.046	0.028	-0.021
	(4.32)***	(3.26)***	(1.97)*	(4.55)***	(4.61)***	(3.83)***
Fund return $_{t-1}$	0.046	0.014	-0.020	-0.045	-0.023	0.028
	(2.27)**	(1.00)	(0.95)	(1.75)*	(2.56)**	(1.58)
R^2	0.09	0.10	0.22	0.12	0.12	0.08
N	8,742	8,742	8,742	8,742	8,742	8,742

Panel B: Mixed Funds

	Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal QE Allocation	Abnormal Non-QE Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
% SOMA $_{t-1}$	0.076	0.021	-0.003	-0.138	0.011	0.034
	(7.86)***	(4.29)***	(0.36)	(10.60)***	(2.28)**	(4.22)***
% QE $_{t-1}$	0.017	-0.005	-0.279	0.276	-0.012	0.002
	(1.83)*	(0.67)	(11.96)***	(8.40)***	(1.73)*	(0.21)
Fund flows $_{t-1}$	-0.083	-0.032	-0.006	0.150	0.027	-0.056
	(9.58)***	(7.47)***	(1.61)	(10.26)***	(4.56)***	(7.88)***
Fund return $_{t-1}$	0.079	0.003	-0.023	-0.090	-0.013	0.044
	(1.36)	(0.10)	(0.85)	(0.78)	(0.56)	(0.83)
R^2	0.16	0.07	0.39	0.21	0.05	0.11
N	7,781	7,781	7,781	7,781	7,781	7,781

Table 10
Fixed Effects Regressions of Changes in Abnormal Fund Corporate Allocation – Mixed Fund Robustness
The dependent variable in these fixed effect regressions are quarterly changes in the allocation of individual mutual funds to specific asset classes, beyond the allocations that would be expected based on their flows. Column (1) presents the baseline results and columns (2) – (4) present different subsets of funds. Column (2) eliminates any funds classified as index funds by Morningstar. Column (3) eliminates any funds with an Cremers and Petajisto (2009) Active Share below 0.6, while column (4) eliminates those with an Active Share below 0.9. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

Panel A: Mixed Funds – Lagged Effect

	Abnormal Corporate Allocation	Abnormal Corporate Allocation (Non-index)	Abnormal Corporate Allocation (Active Share > 0.6)	Abnormal Corporate Allocation (Active Share > 0.9)
% SOMA $_{t-1}$	0.049	0.049	0.049	0.072
	(4.26)***	(4.17)***	(4.20)***	(5.21)***
% QE $_{t-1}$	0.021	0.022	0.022	0.021
	(1.72)*	(1.78)*	(1.77)*	(0.83)
% SOMA $_{t-2}$	0.032	0.034	0.034	0.028
	(2.98)***	(3.10)***	(3.09)***	(2.47)**
% QE $_{t-2}$	0.005	0.004	0.004	-0.007
	(0.31)	(0.22)	(0.24)	(0.30)
Fund flows $_{t-1}$	-0.085	-0.086	-0.086	-0.076
	(9.82)***	(9.78)***	(9.77)***	(8.96)***
Fund return $_{t-1}$	0.083	0.096	0.097	0.099
	(1.47)	(1.63)	(1.66)	(1.77)*
R^2	0.16	0.16	0.16	0.16
N	8,233	7,873	7,858	6,405

Figure 1

This chart displays the number of individual Treasury CUSIPs the Federal Reserve purchased each quarter as a percentage of the number of Treasury CUSIPs held by mutual funds that quarter. Similarly, it also displays the number of individual Agency CUSIPs the Federal Reserve purchased each quarter as a percentage of the number of Agency CUSIPs held by mutual funds that quarter.

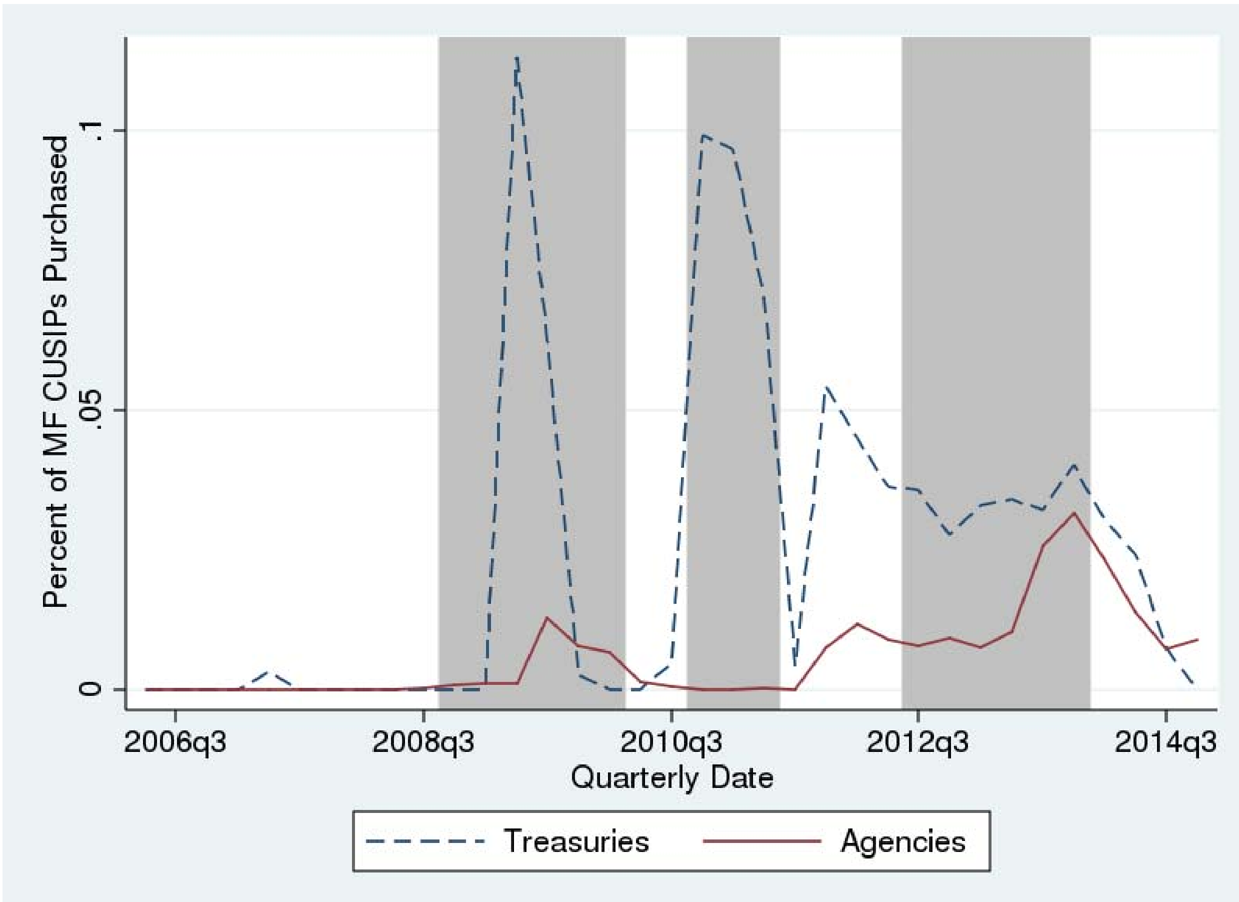

Figure 2

This chart displays changes in fund allocation based on their exposure to quantitative easing. We classify funds based on their exposure to QE purchases. Each quarter, we measure the proportion of the fund's market value that is invested in securities that the Federal Reserve is purchasing. We then divide those funds that have some exposure to QE purchases into quintiles, with funds in the first quintile having the lowest exposure and funds in the fifth quintile having the highest exposure. We measure this allocation change as the dollar change in the fund allocation, as a percentage of the end of the prior quarter's fund assets, less the fund allocation change that could be expected to occur based on fund flows (i.e., the percentage fund flows multiplied by the percentage of the fund's assets invested in the asset class in the prior quarter).

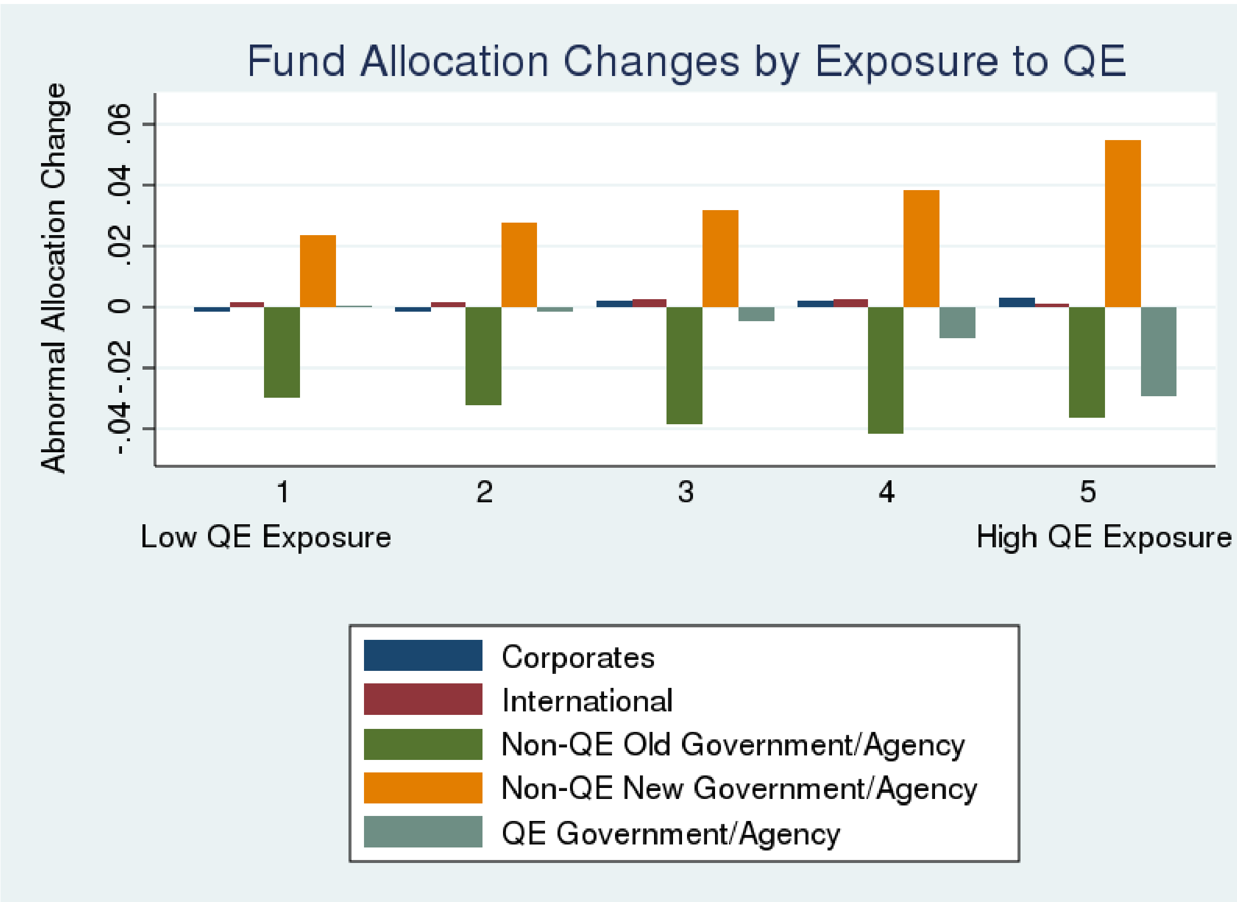

Figure 3

This chart displays the aggregate amount of QE purchases based on the threshold used to classify a change in the SOMA portfolio as a purchase. These thresholds range from 0% of the outstanding stock of a given bond to 5% of the outstanding stock of the bond. For comparison purposes, the figure also displays the quarterly net change in the SOMA portfolio.