Price Impacts of Federal Reserve Balance Sheet*

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Abstract

We decompose fixed income price growth rates in terms of institutional portfolio holdings, based on market-clearing conditions, exploiting data on 80 million security-institution-quarter observations. We show that institutional sectors that are the largest holders are not necessarily the biggest contributors to security price variation. Instead, it is the sectors that are the most price sensitive that contribute the most to the overall price variability. Changes in the size of the Federal Reserve's balance sheet have price impact even beyond the assets held directly by the Federal Reserve. For agency MBS and U. S. corporate bonds, that effect comes primarily through a crowding-in of outside investors, even for security types for which outside investors do not represent a large fraction of overall price variation.

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1 Introduction

The Federal Reserve first announced purchases of agency mortgage-backed securities and debt of government sponsored enterprises on November 25, 2008. More than fifteen years later, the Federal Reserve System's balance sheet remains above $6.7 trillion as of March 2025. This balance sheet size reflects the ebbs and flows of balance sheet policy implemented in the years since the depth of the 2008–2009 financial crisis, as the U. S. central bank (as well as central banks in other major economies) has faced the challenges of stimulating the economy at the (effective) zero lower bound, controlling both the highs and lows of inflation, and keeping inflation expectations anchored.

In the 16 years since the first announcement of a large scale asset purchase program on November 25, 2008, the Federal Reserve has conducted three rounds of quantitative easing, i.e. expansions of its balance sheets, and is currently in a second round of quantitative tightening. Despite this rich history of unconventional monetary policy actions through balance sheet management, the academic literature has not come to a definitive conclusion on the channels through which quantitative easing (QE) affects financial conditions – indeed, there is a debate as to whether quantitative easing affects financial conditions at all – and whether quantitative tightening (QT) simply "undoes" quantitative easing and thus has an impact of a similar magnitude.

In evaluating the effects of QE and QT, the literature has focused on understanding the role of surprises – either in the form of unexpected announcements (Gagnon et al., 2011, and subsequent literature) or in the form of an unexpected flow of purchases for a given security (e.g. Ray et al., 2024; Selgrad, 2023). While surprise changes in balance sheet policy allow for causal identification, such approaches cannot capture the overall effects of the size and composition of the Federal Reserve's balance sheet on the evolution of financial conditions. Furthermore, since QT programs by their nature are much more predictable and decrease the size of the balance sheet at a much slower pace than QE programs expand it,

an approach focused on balance sheet policy surprises is likely to particularly disadvantage the measurement of QT impacts.

In this paper, we take an alternative approach to evaluating the effects of the Federal Reserve's securities holdings on financial conditions by evaluating how holdings of institutional investors change concurrently with changes in Federal Reserve holdings and what effect those changes have on fixed income security prices. We rely on granular (institution – security – date) data on holdings of U. S. Treasuries, U. S. nonfinancial corporate bonds, and U. S. residential agency MBS by individual bank holding companies, insurance companies, and mutual funds. Focusing on changes in portfolio holdings rather than the reaction to policy surprises allows to evaluate how the overall stance of monetary policy affects the evolution of fixed income asset prices.

The methodology that we use to compute price impact of changes to the Federal Reserve balance sheet, based on the approach proposed recently in Rey et al. (2024a), is founded on a minimal set of assumptions: linearization around market-clearing conditions, and the premise that the institutional holdings of our sample of investors accurately reflect the behavior of all investors in U. S. fixed income markets. We show that, our data covers between 40% and 60% of outstanding at the individual security level, and that we can explain upward of 50% of price variation for securities in our sample. This allows us to focus on understanding the contributions to price impact overall and how the impact of the Federal Reserve's balance sheet changes over time and across security types.

We document three big picture results that help inform our understanding of price formation in U. S. fixed income markets and how quantitative easing and tightening programs pass-through into financial conditions not just for securities bought directly by the Federal Reserve but more broadly. We start by showing that large *holders* – institutions or institution types that hold a large fraction of amount outstanding – are not necessarily large from the perspective of price impact. Instead, institutions whose allocations are more likely to be price

sensitive, such as mutual funds and external investors, contribute the most to the overall price variation. In other words, while buy-and-hold investors are more likely to hold large positions, shorter-term investors are more likely to contribute to price variation.

Second, we find that, on average, expansions in the size of the Federal Reserve balance sheet have a price impact even beyond the assets held directly by the Federal Reserve. For agency MBS and U. S. corporate bonds, that effect comes primarily through a crowding-in of outside investors, even for security types for which outside investors do not represent a large fraction of overall price variation. Thus, the channels of transmission of Federal Reserve's liquidity injections may be different from "normal" price variation.

Finally, we show that quantitative tightening effects are asymmetric to those of quantitative easing but not necessarily smaller. For U. S. Treasuries, the price impact of increases in the Federal Reserve's balance sheet is highest during the post-global financial crisis quantitative easing and declines over the subsequent periods. These changes in the price impact are driven by a declining impact of changes in the SOMA portfolio allocation and in the balance sheet size itself. For U. S. corporate bonds, instead, quantitative tightening has a bigger price impact than quantitative easing. This suggests that, for corporate bonds, quantitative easing and tightening operate primarily through the (duration) risk channel rather than the liquidity channel while the opposite is true for U. S. Treasury securities.

Overall, our results highlight that, in evaluating the asymmetry between quantitative easing and quantitative tightening "one size does not fit all". There are important differences across asset classes and investors, and the channels of transmission of changes in the size of the Federal Reserve balance sheet may be different from the channels of transmission of "normal" price variation.

Our paper is related to several strands of the literature. First, our paper is related to the literature studying the impact of central bank balance sheet policies on financial conditions. The empirical literature that evaluates the effects of large scale asset purchases has primarily

focused on an event study strategy. The event study strategy is particularly suited to evaluating the effect of *surprise announcements* of monetary policy actions as the forward-looking nature of financial markets means that changes in the expected future supply of securities and the future path of interest rates are reflected in today's asset prices. As such, the initial quantitative easing (QE1) announcements in November 2008 and March 2009 have proven to provide the most fruitful information on the effectiveness of central bank purchases as the novelty of QE1 plausibly sets it apart from subsequent QE announcements. Various studies (Gagnon et al., 2011; Krishnamurthy and Vissing-Jorgensen, 2011; Neely, 2015; Bauer and Neely, 2014; D'Amico et al., 2012; D'Amico and King, 2013) estimate that, for purchases equivalent to 10 percent of GDP, 10-year yields decline by 40 to 90 basis points. Such purchases imply a similar reaction of yields on lower-rated corporate bonds (Gilchrist and Zakrajšek, 2013), and a somewhat smaller reaction of foreign sovereign debt yields (Neely, 2015). A surprise announcement of purchases of long-term bonds also lowers MBS yield, by around 66 basis points per $1 trillion of purchases announced, as well as mortgage rates (Krishnamurthy and Vissing-Jorgensen, 2011; Hancock and Passmore, 2014); lower the value of the USD and raise both domestic and international stock prices (Kiley, 2014; Neely, 2015; Bowman et al., 2015); and reduce option-implied tail risk (Hattori et al., 2016) and the liquidity risk premium in agency MBS (Boyarchenko et al., 2019).

It is important to note that an event study approach by definition focuses only on the announcement effect of QE and cannot measure, for example, the impact of the flow of purchases or the impact of the overall size and composition of the Federal Reserve's balance sheet. Our paper thus complements this literature by focusing on the average price impact of changes in the size of the Federal Reserve's balance sheet over the lifetime of fixed income securities. Our paper thus connects also with studies that have leveraged cross-sectional security heterogeneity to estimate the differential impact of central bank asset purchases (see e.g. D'Amico and King, 2013; Kandrac and Schlusche, 2013). Our approach likewise is related to but requires fewer assumptions than studies that have pursued a "shock identifi-

cation" strategy to try to quantify the portfolio rebalancing channel or, in other words, the preferred habitat channel. Ray et al. (2024) use high frequency identification from Treasury auctions to construct demand shocks for Treasuries in the primary market that mimic QE and are plausible transmitted through the preferred habitat channel only. Using such demand shocks, Ray et al. (2024) argue that the preferred habitat channel accounts for the majority of the response of financial markets to QE, especially during periods of market stress. Selgrad (2023) likewise constructs QE shocks – based on differences between predicted and actual purchased amounts of individual securities – and finds a large role for the portfolio rebalancing channel, with investors rebalancing towards corporate bonds within their preferred maturity segment in response to Treasury purchases. Such rebalancing leads to a substantial reduction in corporate bond yields, with $100 billion of Treasury purchases corresponding to a 7.8 basis points decline in average bond yields.

Finally, our paper is also related to the literature studying institutional demand in asset markets. Starting with Koijen and Yogo (2019a,b), a number of papers have explored a "demand based" asset pricing approach to analyzing the relationship between investors' asset holdings and equilibrium asset prices. Bretscher et al. (Forthcoming), Chaudhary et al. (2023), Siani (2022), and Darmouni et al. (2022) study corporate bond markets through the lens of demand based asset pricing, while Koijen et al. (2021), Fang et al. (2022), Jansen (2025), Jiang et al. (2024), and Jansen et al. (2024) focus on the demand for sovereign debt securities in particular economies, including the U. S. We contribute to that literature by considering the equilibrium implications of asset holdings for price impact from a market clearing perspective – rather than a portfolio allocation perspective – placing our work closer to the approach taken in Gabaix and Koijen (2021) to measuring aggregate price impact in U. S. equity markets. Furthermore, we focus on how institutions participate across different fixed income markets in the U. S. (U. S. Treasuries, agency MBS, and nonfinancial corporate bonds), rather than restricting our estimation to one asset type only. This is particularly important in evaluating the pass-through of monetary policy to other fixed income markets.

The rest of the paper is organized as follows. Section 2 describes the empirical methodology for measuring price impact in our setting. We discuss the data sources and construction of the sample in Section 3. We present the full-sample estimation results in Section 4, and evaluate the effectiveness of quantitative easing and tightening in Section 5. Section 6 concludes.

2 Market clearing approach to measuring price impact

In this section, we describe the theoretical underpinnings of the decomposition of asset price changes in terms of equilibrium holdings. We follow to a large extent the approach proposed in Rey et al. (2024a,b) but adopt it to our setting of fixed income markets. In a nutshell, the Rey et al. (2024a) approach centers on using the market clearing condition for each security, and decomposing changes in market value of outstanding into changes in portfolio allocations and investor wealth. Relative to the Rey et al. (2024a,b) setting of international equity holdings, the market for U. S. fixed income assets posses additional challenges. First, while Rey et al. (2024a,b) are able to focus on mutual fund holdings as a representative investor class, the set of investors that participate in U. S. fixed income markets is much more diverse. Our holdings data thus covers not only mutual funds but also other investor types including insurance companies, large bank holding companies, and the Federal Reserve. Second, our mix of investor types has a mix of accounting standards that they use in reporting holdings, ranging from mark-to-market, to amortized cost, to hold-to-maturity accounting. Our decomposition thus has to account for these different valuation standards. Finally, unlike equity securities, fixed income securities have a finite maturity, which generates a "pull to par" in the security price. We now describe our implementation of the basic idea of Rey et al. (2024a) in the setting of U. S. fixed income assets.

2.1 Individual security price decomposition

For an instrument i at date t, we start with the simple market clearing constraint

$$P_{i,t}Q_{i,t} = \sum_{n \in \mathcal{N}_{i,t}} \omega_{i,n,t} S_{i,n,t} W_{n,t} + F_{i,t} + O_{i,t}, \tag{1}$$

where $P_{i,t}$ is the market price of instrument i, $Q_{i,t}$ is the amount outstanding of instrument i, $\mathcal{N}_{i,t}$ is the universe of observed private investors holding security i at date t, $F_{i,t}$ is the market value outstanding held by the Federal Reserve, and $O_{i,t}$ is the market value outstanding held by outside investors. We denote by $\omega_{i,n,t}$ the share of investable assets $W_{n,t}$ of investor n allocated to security i, and by $S_{i,n,t}$ the accounting "exchange rate" that translates the accounting value of institution n's holding of security i into the corresponding market value. Dividing both sides of (1) by the amount outstanding at each date t, we thus have

$$P_{i,t} = \sum_{n \in \mathcal{N}_{i,t}} \frac{\omega_{i,n,t}}{Q_{i,t}} S_{i,n,t} W_{n,t} + \frac{F_{i,t}}{Q_{i,t}} + \frac{O_{i,t}}{Q_{i,t}}.$$

We linearize market clearing condition (1) with respect to the portfolio shares, and log-linearize with respect to the investors' investable assets, the accounting exchange rate, and the instrument price.We thus have

$$\Delta p_{i,t} = \sum_{n \in \mathcal{N}_{i,t}} \underbrace{\overline{\omega}_{i,n} \overline{S}_{i,n} \overline{W}_n}_{\mu_{i,n}} (\Delta \omega_{i,n,t} + \Delta s_{i,n,t} + \Delta w_{n,t}) + \overline{F}_i \Delta f_{i,t} + \overline{O}_i \Delta o_{i,t}, \tag{2}$$

where $P_{i,0}$ is the sample average of $P_{i,t}$, $\overline{F}_i$ is the sample average of $F_{i,t}/\left(P_{i,0}Q_{i,t}\right)$, $\overline{O}_i$ is the sample average of $O_{i,t}/\left(P_{i,0}Q_{i,t}\right)$, $\overline{\omega}_{i,n}$ is the sample average of $\omega_{i,n,t}/\left(P_{i,0}Q_{i,t}\right)$, $\overline{S}_{i,n}$ is the sample average $S_{i,n,t}$, and $\overline{W}_n$ is the sample average of investor n's investable assets. Here $\mu_{i,n}$ is the relative average importance of investor n for the market value of asset i.

We can further simplify the decomposition (2) by considering commonalities across groups

of investors. In particular, we group institutions by type – bank holding companies, life insurance companies, property and casualty (P&C) insurance companies, money market mutual funds (MMMF), ETFs, and other mutual funds. Denote by $\mathcal{T}_{i,\tau,t}$ the set of investors of type τ at date t invested in security i,fit and by $N_{i,\tau,t}$ the total number of such investors. Without loss of generality, for any investor $n \in \mathcal{T}_{i,\tau,t}$, we can represent

$$\begin{aligned}
\Delta\omega_{i,n,t} &= \frac{1}{N_{i,\tau,t}} \sum_{k \in \mathcal{T}_{i,\tau,t}} \Delta\omega_{i,k,t} + \epsilon_{\omega,i,n,t} \equiv \overline{\Delta\omega}_{i,\tau,t} + \epsilon_{\omega,i,n,t} \\
\Delta s_{i,n,t} &= \frac{1}{N_{i,\tau,t}} \sum_{k \in \mathcal{T}_{i,\tau,t}} \Delta s_{i,k,t} + \epsilon_{s,i,n,t} \equiv \overline{\Delta s}_{i,\tau,t} + \epsilon_{s,i,n,t} \\
\Delta w_{n,t} &= \frac{1}{N_{\tau,t}} \sum_{k \in \mathcal{T}_{\tau,t}} \Delta w_{n,t} + \epsilon_{w,n,t} \equiv \overline{\Delta w}_{\tau,t} + \epsilon_{w,n,t}.
\end{aligned}$$

That is, we can represent, for example, the contribution to price variation from the allocation choices of investor n into the contribution from the common allocation choices of investors of type τ and the allocation choice that is idiosyncratic to investor n relative to their peers in their own institution type. Substituting into (2), we have

$$\begin{aligned}
\Delta p_{i,t} &= \sum_{\tau} \sum_{n \in \mathcal{T}_{i,\tau,t}} \mu_{i,n} \left(\overline{\Delta\omega}_{i,\tau,t} + \overline{\Delta s}_{i,\tau,t} + \overline{\Delta w}_{\tau,t} + \epsilon_{\omega,i,n,t} + \epsilon_{s,i,n,t} + \epsilon_{w,n,t} \right) + \overline{F}_i \Delta f_{i,t} + \overline{O}_i \Delta o_{i,t} \\
&= \sum_{\tau} \mu_{i,\tau} \left(\overline{\Delta\omega}_{i,\tau,t} + \overline{\Delta s}_{i,\tau,t} + \overline{\Delta w}_{\tau,t} + \bar{\epsilon}_{\omega,i,n,t} + \bar{\epsilon}_{s,i,n,t} + \bar{\epsilon}_{w,n,t} \right) + \overline{F}_i \Delta f_{i,t} + \overline{O}_i \Delta o_{i,t},
\end{aligned}$$

where

$$\bar{\epsilon}_{\cdot,i,n,t} = \sum_{n \in \mathcal{T}_{i,\tau,t}} \frac{\mu_{i,n}}{\mu_{i,\tau}} \epsilon_{\cdot,i,n,t}$$

is the weighted-average idiosyncratic deviation within institution type τ. We can similarly further decompose the contribution from the market-value of the SOMA portfolio into changes in the fraction "allocated" to security i and the overall growth in the size of the

Federal Reserve's balance sheet:

$$\Delta f_{i,t} = \Delta \omega_{i,f,t} + \Delta A_t,$$

so that our final log-linear price approximation is

$$\begin{aligned}\Delta p_{i,t} = \sum_{\tau} \underbrace{\mu_{i,\tau}\left(\overline{\Delta\omega}_{i,\tau,t} + \overline{\Delta s}_{i,\tau,t} + \overline{\Delta w}_{\tau,t} + \bar{\epsilon}_{\omega,i,n,t} + \bar{\epsilon}_{s,i,n,t} + \bar{\epsilon}_{w,n,t}\right)}_{\text{Investor type } \tau \text{ contribution}=\Delta MV_{i,\tau,t}} \\ + \overline{F}_i\left(\Delta\omega_{i,f,t} + \Delta A_t\right) + \overline{O}_i \Delta o_{i,t}.\end{aligned} \tag{3}$$

We use (3) in two ways. First, (3) allows us to decompose the overall variation in the price of security i into contributions from each investor class:

$$\mathbb{V}\left(\Delta p_{i,t}\right) = \sum_{\tau} \mathbb{C}\left(\Delta p_{i,t}, \Delta MV_{i,\tau,t}\right) + \mathbb{C}\left(\Delta p_{i,t}, \overline{F}_i \Delta f_{i,t}\right) + \mathbb{C}\left(\Delta p_{i,t}, \overline{O}_i \Delta o_{i,t}\right). \tag{4}$$

The variance decomposition (4) allows us to study which types of investors are important for price variation in each security (or in each security market).

Second, (3) allows us to decompose the price impact of changes in the wealth of one investor (or one investor type) into its effects on the portfolio allocation of other investors. For example, the impact of changes in the size of the Federal Reserve's balance sheet on the price of security i can be decomposed into

$$\begin{aligned}\mathbb{C}\left(\Delta p_{i,t}, \Delta A_t\right) = &\sum_{\tau} \mu_{i,\tau}\left(\mathbb{C}\left(\Delta A_t, \overline{\Delta\omega}_{i,\tau,t}\right) + \mathbb{C}\left(\Delta A_t, \overline{\Delta s}_{i,\tau,t}\right) + \mathbb{C}\left(\Delta A_t, \overline{\Delta w}_{\tau,t}\right)\right) \\ &+ \sum_{\tau} \mu_{i,\tau}\left(\mathbb{C}\left(\Delta A_t, \bar{\epsilon}_{\omega,i,n,t}\right) + \mathbb{C}\left(\Delta A_t, \bar{\epsilon}_{s,i,n,t}\right) + \mathbb{C}\left(\Delta A_t, \bar{\epsilon}_{w,n,t}\right)\right) \\ &+ \mathbb{C}\left(\Delta A_t, \overline{F}_i \Delta\omega_{i,f,t}\right) + \mathbb{C}\left(\Delta A_t, \overline{F}_i \Delta A_t\right) + \mathbb{C}\left(\Delta A_t, \overline{O}_i \Delta o_{i,t}\right).\end{aligned} \tag{5}$$

That is, we can decompose the price impact of Federal Reserve holdings into their covariance

with the common variation in holdings and assets of institutions of a particular type (first row), the contributions from weighted average deviations from those averages (second row), and the contribution of external investors and changes in amount outstanding (third row). Importantly, (5) allows us to evaluate price impact not just for securities held directly by the Federal Reserve but also for other securities held by other fixed income investors.

2.2 Aggregate price impact

In order to study which investors are the key drivers of the overall variation in fixed income prices, we aggregate equation (3) across securities, constructing a weighted average of price growth rates and their subcomponents. The weights used are the sample average valuation over the lifetime of each security relative to the total market valuation of all securities of a given type. In particular, for a security i, we define $\nu_{i,t} = \frac{P_{i,0}Q_{i,t}}{\sum_{j\in\mathcal{J}_{\sigma,t}} P_{j,0}Q_{j,t}}$, where $\mathcal{J}_{\sigma,t}$ is the set of securities of the same type σ as security i at date t. Then the weighted-average sum of price changes for instruments of type σ is

$$\Delta p_{\sigma,t} = \sum_{i\in\mathcal{J}_{\sigma,t}} \nu_{i,t} \sum_{\tau} \Delta MV_{i,\tau,t} + \sum_{i\in\mathcal{J}_{\sigma,t}} \nu_{i,t}\overline{F}_i \left(\Delta\omega_{i,f,t} + \Delta A_t\right) + \sum_{i\in\mathcal{J}_{\sigma,t}} \nu_{i,t}\overline{O}_i \Delta o_{i,t}.$$

2.3 Relation to the demand-based asset pricing literature

It is worth discussing the differences between the approach in Rey et al. (2024a) that we adapt here to evaluate the impact of Federal Reserve balance sheet policy and other approaches that link institutional holdings with asset price variations. Our decomposition (3) of prices into contributions from changes in portfolio allocations, investor wealth and accounting "exchange" rates (and the similar decomposition in Rey et al., 2024a) relies only on the market clearing constraint, taking portfolio allocation choices as given. This allows us to consider cross-security price impact without making assumptions on substitutability

across assets (or asset classes).

Koijen and Yogo (2019a,b) and the subsequent literature, instead, directly model institutions' portfolio choices as a function of security characteristics and asset prices. These demand-based estimations posit specific forms of substitution across assets, and thus may limit our ability to uncover the full effects of central bank balance sheet programs. Furthermore, this literature generally finds that price variation is to a large extent due to the latent demand for securities; that is, the part of demand that cannot be explained by asset or investor characteristics.

3 Data

An important aspect of our approach is a comprehensive datasets linking holdings of U. S. fixed income securities, yields, and characteristics. We improve on prior studies in two ways. First, we consider investments across different types of fixed income securities – U. S. Treasuries, agency MBS, and corporate bonds – while most papers in the literature have focused on one type of fixed income securities at a time. Second, we include security-level holdings of large bank holding companies in the U. S. in our estimation of price impacts. Given our focus on fixed income markets, including government securities, accurately capturing holdings by banks is particularly important. We put together data on asset holdings, asset prices, and asset characteristics from several data sources. Our final dataset covers 1,651 unique U. S. Treasury cusips, 534,650 unique MBS cusips, and 21,274 unique corporate bond cusips, representing almost 80 million security-institution-quarter observations.

3.1 Holdings data

We use data on insurance company and mutual fund holdings from eMaxx. eMaxx groups institutions into several broad types, such as open-end mutual funds, closed-end mutual funds, life insurance companies, and property and casualty insurance companies. We identify ETFs and index mutual funds in the open-end mutual fund universe by searching for funds that include "ETF", "Exchange", or "Index" in their name. We further follow the eMaxx classification, and consider variable annuities – both those that invest in mutual funds and those that invest in money market mutual funds – separately from both insurance accounts and mutual fund accounts. Finally, we group all the remaining investors included in eMaxx into the "other eMaxx" category.

Since we are interested in the transmission of monetary policy, including information on securities holdings of banks is crucially important. We use the FR Y-14Q Schedule B data on the securities portfolios of bank holding companies subject to stress testing in the U. S. We match bank securities holdings with bank balance sheet data from FR Y9C data, which allows us to measure reserves. The (earliest) FR Y-14 data became available in March 2009,[1] limiting our empirical analysis to start on 2009 Q1.

Finally, we obtain SOMA holdings from the Federal Reserve Bank of New York.

3.2 Pricing data

We use secondary market quotes from ICE Global Bond Indices. As noted in Kelly et al. (2023), ICE data is considered the "gold standard" for fixed income pricing data because of the breadth of coverage relative to data on transactions-based prices and the analytics provided as part of the ICE dataset.

[1] The 2009 data is based on the "Supervisory Capital Assessment Program" (SCAP), which targeted a smaller set of large banks compared to the "Comprehensive Capital Analysis and Review" (CCAR) data that was later introduced in 2011 with more detailed data and stricter reporting requirements.

We define our universe of corporate bonds to be the underlying constituents at a monthly frequency from the ICE Global Corporate Index (G0BC) and ICE Global High Yield Corporate Index (HW00). The underlying constituents data includes effective option-adjusted spread, duration, and month-to-date returns for each bond-day, as well as bond and issuer characteristics, such as issuer domicile, issuer industry, currency of issuance, coupon type and rate, bond seniority, and call and put provisions. We use bonds issued by non-financial ultimate parents domiciled in the U. S. as our set of non-financial corporate bonds.

We use MBS pricing data for the underlying constituents of the ICE U. S. Mortgage Backed Securities Index (M0A0). The ICE U. S. Mortgage Backed Securities Index includes residential mortgage pass-through securities issued by all three Federal Agencies with at least one year remaining time to maturity and a minimum amount outstanding of $5 billion per each generic coupon.

Finally, we obtain pricing data on U. S. Treasuries from the ICE 0 – 1 year U. S. Treasury Index (G0QA) and the ICE U. S. Treasury Index (G0Q0), with the latter index including securities with at least a year remaining time-to-maturity and at least 18 months time-to-maturity at issuance.

3.3 Summary statistics

Table 1 reports the summary statistics of the holdings in our sample across all three asset classes we consider. The number of individual accounts covered by eMaxx and investing in either U. S. Treasuries or U. S. nonfinancial corporate bonds doubles from the start of our sample in 2009 to the end in 2022. For an average U. S. Treasury in our sample, around 16% of its market value is held by the private institutions covered in our sample and a further 22% by the Federal Reserve. Out of the 16% held on average by private institutions, 4.25% is held by bank holding companies and 11.75% by institutions captured in eMaxx.

Although individual U. S. Treasuries tend to appear in both private institutions' balance sheets and the Federal Reserve's balance sheet, the same is not true for individual MBS cusips. For MBS cusips held by private institutions, our institutions hold on average 34% of market value outstanding, with bank holding companies representing more than 9% on average and the institutions in eMaxx 25%. For those cusips, the average holding by the Federal Reserve is about 2% of market value outstanding. In contrast, the Federal Reserve holds on average 65% of the market value of agency MBS not appearing on the private institutions' balance sheets. This highlights that, especially for agency MBS, it is important to capture both private and central bank holdings at the security level and that analyses that focus on within-security impact of central bank purchases are likely hampered by holding segmentation.

Finally, Table 1 shows that, although their positions may be small, U. S. large bank holdings hold a substantial number of individual corporate bonds, suggesting that including them may be important for capturing price dynamics in the corporate bond market as well.

Figure 1– 3 plot the time series of the composition of investors and the amount outstanding covered by our data for Treasury securities, 30-year residential agency MBS, and U. S. non-financial corporate bonds. The figures show substantial variation in both the overall composition of investors by asset class and time variation in that composition. As expected, during our sample, the Federal Reserve is the biggest individual (domestic) investor in Treasury notes and bonds, bank holding companies are substantial investors in agency MBS, and insurance companies and mutual funds are the biggest investors in U. S. non-financial corporate bonds. Notably, ETFs (including index funds) are an increasing share of holdings across all asset classes.

4 Baseline results

We start by using the price variance decomposition (4) to evaluate which investor classes contribute the most to price variation for each security type. In particular, for each investor class τ, we estimate

$$\Delta MV_{i,\tau,t} = \alpha_i + \beta_\tau \Delta p_{i,t} + \text{Security characteristics}_{i,t} + \epsilon_{i,\tau,t} \tag{6}$$

where α_i is a security fixed effect and $\beta_\tau = \mathbb{C}\left(\Delta p_{i,t}, \Delta MV_{i,\tau,t}\right) / \mathbb{V}\left(\Delta p_{i,t}\right)$ measures the contribution of investor type τ to the variance of the price of security i. We estimate (6) separately for each asset class: Treasury bonds, Treasury notes, Freddie Mac (FHL) MBS, Fannie Mae (FNM) MBS, Ginnie Mae (GNM) MBS, corporate bonds rated higher than BBB (investment grade excluding BBB), BBB-rated corporate bonds, BB-rated corporate bonds, and high yield bonds rated lower than BB (high yield bonds excluding BB). We separate BBB-rated corporate bonds because of their greater price sensitivity: downgrade below BBB might force institutional investors, such as insurance firms, with mandates that penalize them for holding below investment grade bonds to offload the bond, leading to a sharp drop in price; an upgrade to BBB, on the other hand, can lead to price appreciation.

Table 2 reports the results from (6) for U. S. Treasury and agency MBS securities. Starting with the variance decomposition for the prices of U. S. Treasury notes and bonds in panels (a) and (b), we see that over 2009 Q1 – 2023 Q4, on average, most of the price variation is explained by contributions from changes in SOMA holdings and changes in the holdings of the outside investors. This should not be surprising given the holding decomposition in Figure 1. For Treasury bonds, changes in SOMA holdings explain on average 65% of the price variation; for Treasury notes, changes in SOMA holdings explain on average 47% of the price variation. Furthermore, ETFs are the largest private investor class contributing to Treasury bond price variation (8% on average).

Turning to agency MBS in panels (c) –(e), we see that, despite being large holders, outside investors do not contribute much to the price variation of any of the three 30-year residential agency MBS asset classes we consider (i.e., FHL, FNM, and GNM). Similarly, even though banks are the largest private investor class for residential agency MBS, their holdings do not contribute significantly to price variation. Instead, for all three agencies, the largest contributors to price variation are mutual funds and ETFs, with mutual funds representing on average 90% of the price variation for FHL MBS, 65% for FNM MBS, and 95% of the price variation of GNM MBS. These results highlight that price variation is not necessarily driven by investors that hold the most of that asset class but rather by the investors that are most likely to be price sensitive themselves.

Table 3 similarly shows that the biggest holders of U. S. non-financial corporate bonds are not necessarily the biggest contributors to price variation. ETFs are the biggest contributors to price variation for the safest corporate bonds (above BBB), with ETF holdings explaining 53% of price variation on average. Outside investors (33%) and mutual funds (12%) are the next biggest contributors to price variation of highly rated corporate bonds. For the other three broad rating categories, the outside investors are the biggest contributors, representing 69% of average price variation in BBB bonds, 80% of price variation in BB bonds, and 70% of price variation of high yield bonds. Mutual funds and/or ETFs, however, also continue to explain a substantial portion of price variation as we move down the credit rating spectrum, with the contribution of mutual funds largest for the two high yield categories (30% and 33% for BB and below BB high yield, respectively).

So what impact has the size of the Federal Reserve's balance sheet had on average for prices of fixed income assets over this time period? To answer that question, we estimate

$$\Delta p_{i,t} = \alpha_i + \beta_{\text{SOMA}} \Delta \text{SOMA}_t + \text{Security characteristics}_{i,t} + \epsilon_{i,\tau,t}, \tag{7}$$

where, as before, α_i is a security fixed effect and Δ SOMA$_t$ is the log-deviation of the size

of the Federal Reserve's balance sheet. Table 4 reports the estimated coefficients β_{SOMA} from the above regression across the different asset classes in our sample. The table shows that increases in the size of the Federal Reserve's balance sheet have an impact even beyond securities directly held by the Federal Reserve. Across the nine asset classes we consider, we find that changes in the size of the Federal Reserve's balance sheet does not have a statistically significant impact on price changes only for Freddie Mac agency MBS and highly rated (above BBB) corporate bonds. Within the corporate bond space, changes in the size of the Federal Reserve balance sheet have a bigger impact on prices of riskier securities.

To summarize, the baseline (full sample) results in Tables 2– 4 suggest that large *holders* of fixed income securities are not necessarily the ones that have the biggest price impact and that expansions in the size of the Federal Reserve balance sheets have implications beyond the assets (and asset classes) directly held by the Federal Reserve. We now investigate the price impact of the Federal Reserve's balance sheet in greater detail.

5 Federal Reserve balance sheet and price impact

5.1 Which sectors adjust?

As discussed above, the market clearing approximation (3) allows us to not only study the contribution of different types of investors to price variation but to also examine how adjustments by different sectors contribute to the price impact of changes in the size of the Federal Reserve balance sheet. Similarly to the price variance decomposition, we compute the components of the price impact decomposition by estimating, for each investor class τ,

$$\Delta MV_{i,\tau,t} = \alpha_i + \beta_\tau \Delta A_t + \text{Security characteristics}_{i,t} + \epsilon_{i,\tau,t}. \tag{8}$$

Starting as before with the contributions to price impact for U. S. Treasuries and agency MBS in Table 5, we see that, for U. S. Treasury bonds and notes the overall price impact we saw in Table 4 is primarily composed of the contributions from changes in the SOMA portfolio itself and changes in the holdings of the outside investors. Increases in the size of the Federal Reserve balance sheet contribute positively to the overall price impact but are partially offset by changes in the holdings of outside investors. This corresponds to these two sectors representing the biggest fraction of price variation for U. S. Treasuries, as we saw in Table 2.

Turning to agency MBS in panels (c) – (e), we see that the picture is somewhat different. A large part of the positive price impact from changes in the size of the Federal Reserve balance sheet comes from the response of the outside investors. That is, while increases in the size of the Federal Reserve balance sheet substitute marginally for contributions of the banking sector, their biggest effect appears to be the "crowding in" of outside investors. Notice that Panels (c) – (d) also show that the direct effect of increases in the Federal Reserve balance sheet – that is, the contribution to the overall price impact from the SOMA portfolio itself – is negative, as the relative share of agency MBS in the Federal Reserve's balance sheet declines as the balance sheet grows.

Table 6 shows the contributions to price impact for corporate bonds. Similarly, it shows that the first order contribution to the overall price impact of increases in the Federal Reserve balance sheet is through a crowding in of the outside investors. For highly rated (above BBB) corporate bonds, the price increase due to outside investors is fully offset by the response of ETFs and mutual funds, so that outside investors are substituting for ETFs and mutual funds when the Federal Reserve's balance sheet size increases. For the remaining credit rating categories, covered investors are also contributing negatively to the price impact of increases in the Federal Reserve balance sheet but the magnitude is much lower than the positive contribution of the outside investors, leading to an overall positive price impact.

Thus, even though mutual funds and ETFs are the significant contributors to the overall price variation of corporate bonds, the transmission of Federal Reserve balance sheet size changes to corporate bond prices occurs through adjustments of other investors.

5.2 How has price impact changed across sub-periods?

The discussion so far has focused on full sample results for our entire covered history from 2009 Q1 to 2023 Q4. We now investigate how the price impact of the size of the Federal Reserve balance sheet changes across different phases. In particular, we consider changes in price impact between quantitative easing, quantitative tightening, and intervening sub-periods. We estimate separately price impact for QE1 through QE3 (Q1 2009 – Q3 2014), QT1 (Q4 2017 – Q3 2019), QE4 (Q1 2020 – Q1 2022), and QT2 (Q2 2022 – Q3 2023), with the intervening periods (Q4 2014 – Q3 2017, Q4 2019), when the Federal Reserve was engaged in neither quantitative easing or quantitative tightening, as our baseline category.

Table 7 reports the estimated coefficients from the regression (7) – augmented with sub-period dummy interactions – of the price impact of increases in the size of the Federal Reserve balance sheet. The table shows an asymmetric magnitude of price impact during QE and QT periods. Furthermore, the table shows a differential impact of QE4 from the prior three quantitative easing programs. Consider first the difference in the price impact during QE1–3 relative to the "status quo" baseline (second row of coefficients). For U. S. Treasuries, FannieMae and GinnieMae MBS, and investment grade non-financial corporate bonds, the differential price impact is positive and, in the case of Treasury bonds, GinnieMae MBS and highly rated corporate bonds, more than offsets the negative baseline impact (the baseline price impact is positive for the remaining asset classes). That is, during the initial three rounds of quantitative easing, the price impact of increases in the size of the Federal Reserve balance sheet is positive for almost all asset classes and at least as big as the price impact during "normal" periods.

Turning to the estimates during quantitative tightening periods, we see that the picture is much more mixed. For QT1 (third row), the price impact of Federal Reserve balance sheet size changes is *lower* than the price impact during periods in-between QE and QT for U. S. Treasury notes and FannieMae and GinnieMae MBS. For U. S. Treasury bonds and BBB and high yield corporate bonds, the price impact during QT1 is slightly higher than that during the baseline periods but the price impact differential is significantly lower than during QE1–3. In other words, for safer securities, the price impact of increases in the size of the Federal Reserve balance sheet is lower during QT1 than QE1–3, so that quantitative tightening is not simply an "undoing" of quantitative easing. For high yield corporate bonds, the price impact is significantly higher during QT1, so that for these riskier securities the removal of policy accommodation through a decrease in the size of the Federal Reserve's balance sheet is more effective than balance sheet expansions.

The last set of coefficients in Table 7 show that the price impact for riskier and safer securities diverged further during QT2. For U. S. Treasuries, the price impact during QT2 is significantly lower than during the baseline but higher than the baseline and, in the case of BBB and lower rated corporate bonds, even higher than the price impact during QE1 – 3.

To understand further the differential mechanisms through which quantitative easing and quantitative tightening operates, in Table 8 we report the estimated coefficients from the price impact decomposition regression (8), augmented with sub-period dummy interactions, for the contributions from the Federal Reserve holdings and outside investor holdings. We further decompose the contribution from the Federal Reserve holdings into the contributions from the relative allocation to a particular security $\omega_{i,f,t}$ and the overall size of the Federal Reserve balance sheet.

Starting with U. S. Treasury notes in panel (a), we see that the contribution to the price impact from the outside investors is unchanged across all five subperiods. The contribution from Federal Reserve holdings instead is highest during QE1–3 and QT1, and lowest

during QT2. Furthermore, the contribution during QE1–3 is particularly large because the contribution of SOMA portfolio allocation changes and the contribution of changes in the size of the Federal Reserve balance sheet are both particularly large. The contribution of both of these components declines as we move to the subsequent phases of monetary policy implementation, eventually becoming lower than those during the baseline periods. For U. S. Treasury bonds (panel b), the contribution of SOMA holdings to the overall price impact is also largest during QE1–3, stemming from a large contribution in the overall size of the balance sheet. The contribution of the outside investors is similar to the baseline across QE1–3 and QT1, declines during QE4 but is higher during QT2. Finally, for agency MBS, the increases in price impact during QE1–3 appear to be driven by increases in the contribution of outside investors.

6 Conclusion

As the Federal Reserve navigates the transition from an abundant to an ample reserves regime, the question of how the central bank's balance sheet affects financial conditions and through which channels is ever more salient. Answering this question requires understanding the overall price impact of changes in the Federal Reserve's balance sheet, beyond their effects on securities directly held by the Federal Reserve and their effects through surprise timing and quantity of purchases. In this paper, we explored how the effectiveness of Federal Reserve balance sheet policy changes across asset markets and over time, using a novel approach that leverages the richness of fixed income holdings data available.

We show that the largest price impact occurs from portfolio reallocations of price sensitive investors, who are not necessarily the largest holders of securities. This results in differential channels of transmission of balance sheet policies in different markets, as different types of investors are "crowded in" by central bank purchases. Our results also highlight that,

in evaluating the asymmetry between quantitative easing and quantitative tightening "one size does not fit all". While the price impacts of changes in the Federal Reserve balance sheet decline over time for U. S. Treasuries, they increase over time for corporate bonds, suggesting that, althogh the liquidity provision channel most likely dominates monetary policy transmission in the former market, the (duration) risk premium channel dominates in the latter.

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Figure 1. Treasury security holders. This figure plots the composition of the holders of U. S. Treasury securities by security type. "VA" are variable annuities. "Oth. eMaxx" are holders captured in the eMaxx database other than the types listed. "Outside investors" measured as the difference between the amount outstanding and the covered universe.

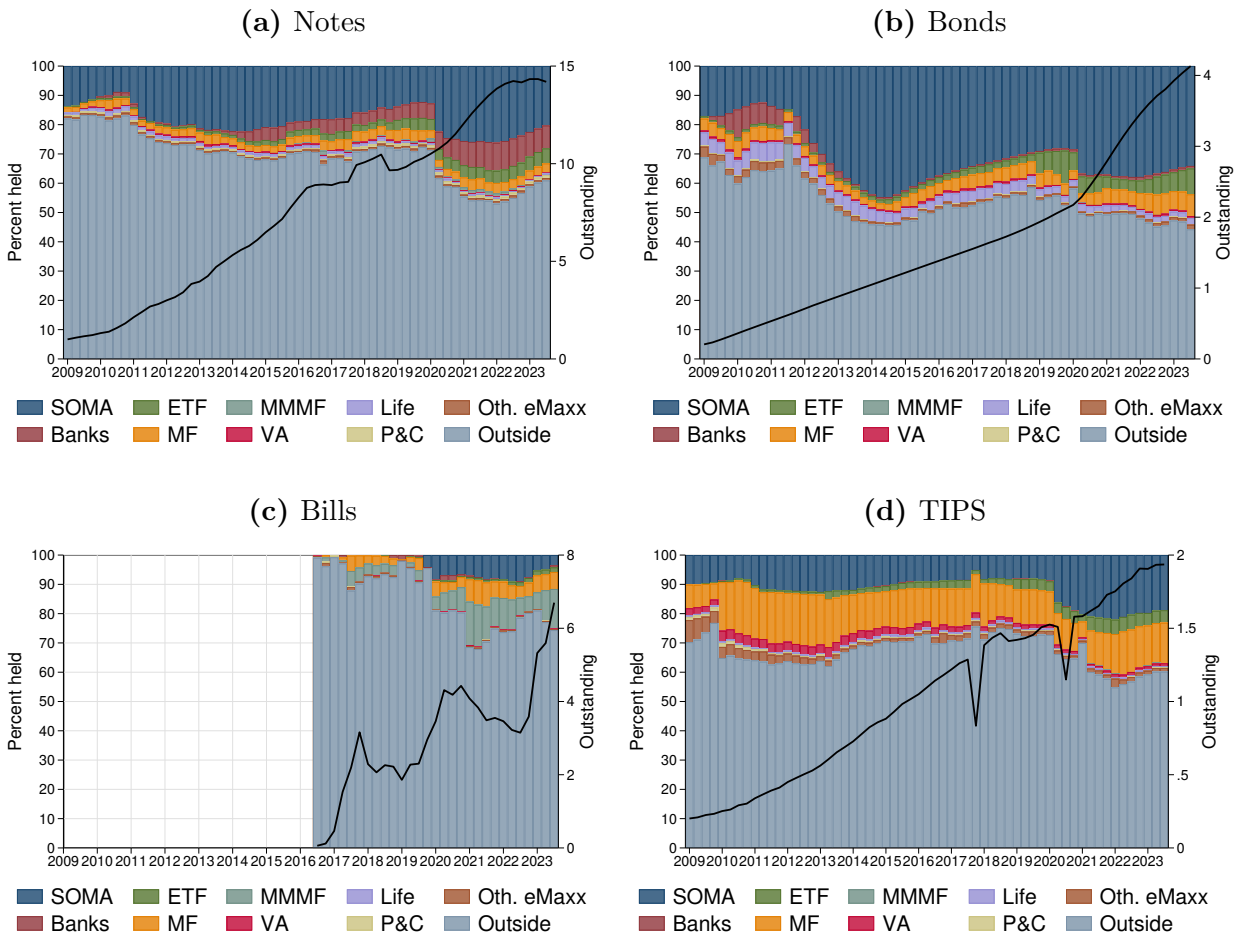


Figure 2. Agency MBS security holders. This figure plots the composition of the holders of U. S. agency MBS securities by security type. "VA" are variable annuities. "Oth. eMaxx" are holders captured in the eMaxx database other than the types listed. "Outside investors" measured as the difference between the amount outstanding and the covered universe.

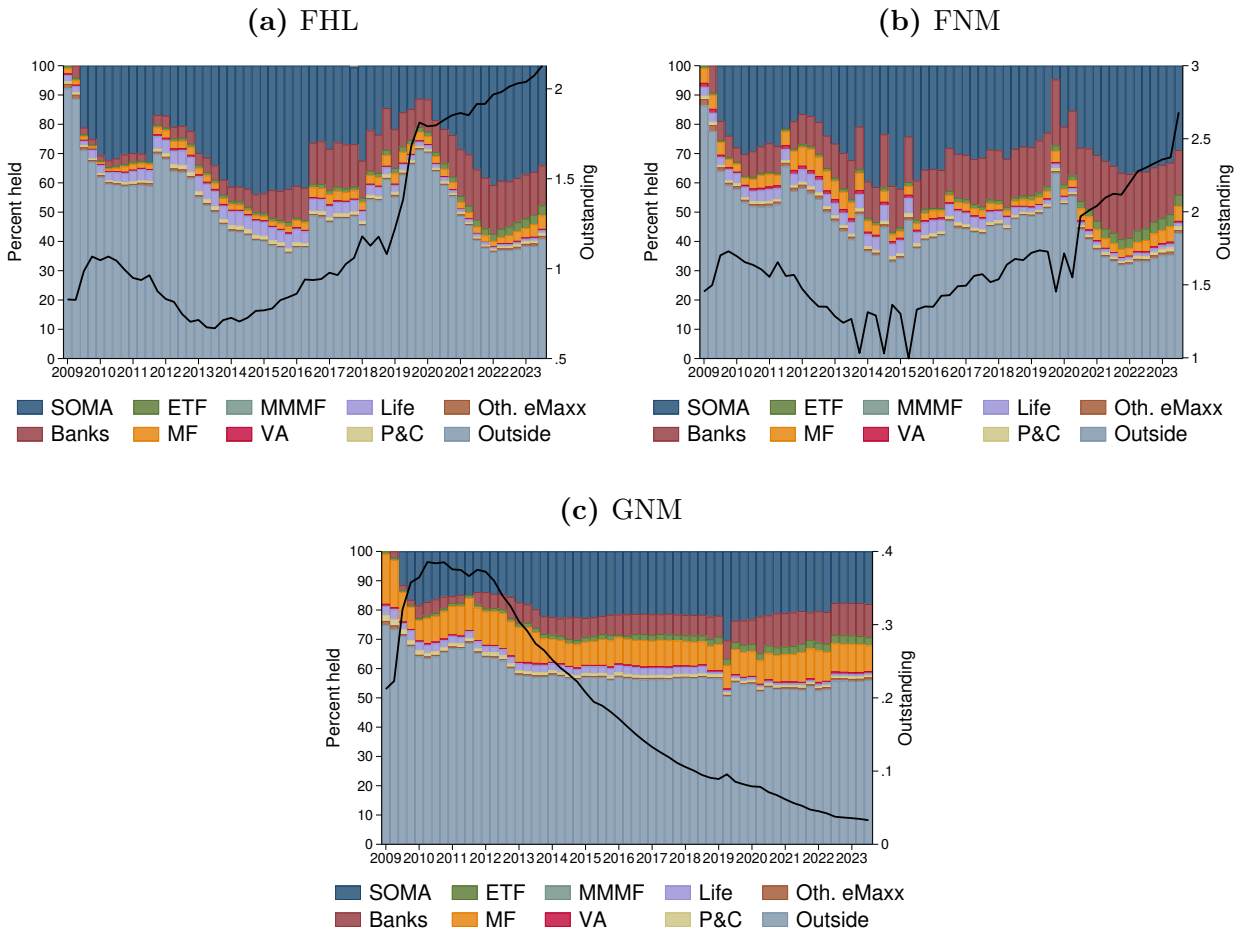


Figure 3. U. S. non-financial corporate bond holders. This figure plots the composition of the holders of U. S. non-financial corporate bonds by rating. "VA" are variable annuities. "Oth. eMaxx" are holders captured in the eMaxx database other than the types listed. "Outside investors" measured as the difference between the amount outstanding and the covered universe.

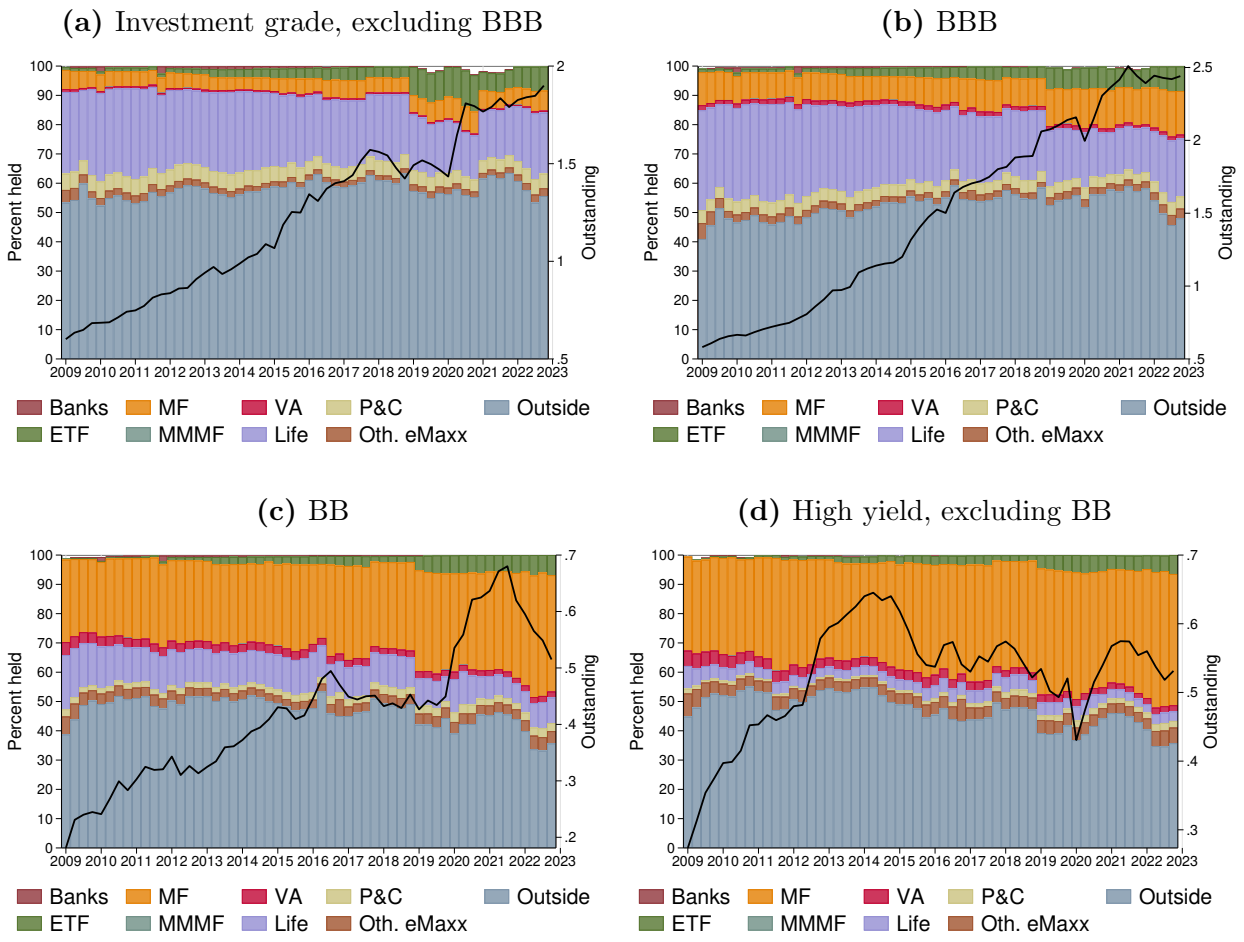


Table 1: Summary statistics of institutional holdings. This table reports the summary statistics of the institutional holdings in our sample. For number of institutions, percent of market value held, and percent of market value held by private institutions, each cell is the panel mean of the security-quarter statistic within the given year. All other statistics as described in column labels. Sample: Q1 2009 – Q4 2022.

(a) U. S. Treasuries

			eMaxx					**BHCs**					**SOMA**
				AUM (USD Million)		N. sec.			Assets (USD Million)		N. sec.		
Year	% held	% held private	N. fund	Median	P90	Median	P90	N. BHC	Median	P90	Median	P90	Mean N. sec
2009	29	15	4,017	109	2,869	7	34	6	1,284,176	2,252,814	16	22	211
2010	32	20	4,407	125	3,716	11	42	10	1,258,128	2,346,601	18	28	239
2011	35	15	4,594	117	3,659	16	61	12	923,718	2,264,436	22	66	269
2012	40	14	4,716	132	4,036	20	80	17	938,770	2,168,023	18	25	270
2013	42	13	4,951	155	4,502	24	97	20	364,021	1,899,511	17	33	259
2014	42	13	5,164	144	4,475	28	121	27	385,303	2,106,796	22	53	255
2015	37	14	5,557	162	4,622	33	161	29	377,371	1,831,801	34	81	266
2016	34	14	6,733	175	4,607	36	194	29	361,187	1,930,115	50	95	290
2017	34	17	7,706	200	4,506	36	210	31	372,357	2,249,046	61	108	333
2018	32	16	7,664	194	4,301	38	213	30	389,749	2,328,754	88	135	364
2019	31	18	8,596	163	3,845	41	220	29	475,775	2,434,079	73	145	372
2020	39	16	8,559	176	4,646	48	221	28	553,905	3,140,887	88	150	421
2021	46	17	8,615	181	5,089	50	238	27	573,284	3,684,256	100	139	431
2022	47	20	8,902	234	5,249	47	253	26	559,496	3,238,223	90	133	437

(b) Agency MBS

			eMaxx					**BHCs**					**SOMA**
				AUM (USD Million)		N. sec.			Assets (USD Million)		N. sec.		
Year	% held	% held private	N. fund	Median	P90	Median	P90	N. BHC	Median	P90	Median	P90	Mean N. sec
2009	31	31	3,829	1,925	47,587	599	15,098	8	1,243,646	2,231,473	16,306	16,770	32,718
2010	36	31	3,720	1,792	38,988	1,005	13,494	11	1,225,862	2,268,347	3,820	16,150	40,910
2011	32	31	3,750	1,783	39,905	892	13,004	12	1,259,734	2,264,436	5,331	16,429	48,840
2012	31	33	3,764	2,347	56,665	685	13,205	18	1,336,204	2,320,164	5,497	16,607	66,400
2013	34	34	3,739	2,597	65,076	666	12,166	24	1,488,055	2,439,494	11,524	16,895	82,030
2014	38	34	3,666	2,428	78,397	626	11,464	30	1,598,874	2,526,655	12,781	16,598	87,804
2015	39	35	3,583	2,314	64,096	567	10,120	32	1,737,737	2,447,994	6,913	16,205	94,756
2016	33	35	3,613	2,335	63,607	541	8,776	31	1,889,235	2,490,972	7,110	16,120	110,375
2017	30	36	3,681	2,277	57,747	538	8,410	31	1,934,939	2,563,074	7,433	17,169	122,503
2018	28	36	3,612	1,806	54,867	440	7,765	29	1,872,981	2,609,785	4,078	13,910	127,059
2019	25	36	3,745	1,515	70,556	338	9,351	28	410,373	2,687,781	2,471	7,809	130,419
2020	22	35	3,802	1,898	65,318	375	8,988	27	540,455	3,214,218	3,668	6,857	135,982
2021	25	38	3,745	1,990	50,764	482	6,944	26	573,284	3,684,256	4,525	9,652	137,860
2022	26	37	3,663	2,153	37,903	599	5,948	26	674,805	3,773,884	4,701	9,351	137,972

(c) Nonfinancial corporate bonds

		eMaxx					**BHCs**				
			AUM (USD Million)		N. sec.			Assets (USD Million)		N. sec.	
Year	% held private	N. fund	Median	P90	Median	P90	N. BHC	Median	P90	Median	P90
2009	52	5,378	491	12,789	190	569	6	1,862,392	2,252,814	367	535
2010	50	5,624	526	12,782	228	1,105	7	1,258,128	2,341,160	511	1,355
2011	51	5,810	607	12,628	254	1,232	9	1,244,666	2,136,578	536	1,824
2012	49	5,968	670	15,138	266	1,179	13	1,333,799	1,944,423	388	574
2013	49	6,094	728	16,110	297	1,340	15	1,436,634	1,899,511	439	670
2014	48	6,221	791	16,863	311	1,510	17	1,546,707	1,894,390	469	712
2015	49	6,543	785	18,155	318	1,570	17	1,731,210	1,831,801	531	715
2016	48	7,776	791	18,224	331	1,662	15	813,891	1,930,115	346	526
2017	48	8,895	786	18,685	335	1,494	15	832,391	1,951,564	271	410
2018	48	8,685	767	16,594	343	1,578	14	382,198	1,922,104	259	305
2019	49	10,387	696	14,594	351	1,807	14	373,275	1,988,226	173	266
2020	48	10,280	771	16,058	406	1,935	15	314,706	2,234,459	132	309
2021	45	10,236	815	16,747	427	2,149	14	314,624	2,327,868	135	290
2022	53	10,175	909	18,212	431	2,385	13	191,826	557,294	145	253

Table 2: Baseline price variation decomposition: U. S. Treasuries and agency MBS . This table reports the baseline price variation decomposition based on (2) into contributions from each holder sector. All regressions include security fixed effects. Treasury regressions also include term fixed effects; agency MBS regressions include vintage year fixed effects. Hodrick (1992) standard errors reported in parentheses below point estimates. *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

(a) TSY notes

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δp	0.011**	0.011***	-0.008*	-0.007***	-0.003***	-0.014***	-0.002***	-0.005***	0.469***	0.635***
	(0.005)	(0.003)	(0.004)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.041)	(0.030)
Adj. R-sqr.	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.00	0.07	0.19
N. of obs	9,602	9,602	9,602	9,602	9,602	9,602	9,602	9,602	9,602	9,602

(b) TSY bonds

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δp	0.006***	0.082***	-0.006*	0.000	-0.000	-0.006	-0.002***	0.001	0.657***	0.396***
	(0.002)	(0.011)	(0.003)	(0.000)	(0.000)	(0.004)	(0.000)	(0.001)	(0.079)	(0.047)
Adj. R-sqr.	0.02	0.10	0.00	0.00	0.00	0.00	0.02	0.00	0.17	0.14
N. of obs	2,634	2,634	2,634	2,634	2,634	2,634	2,634	2,634	2,634	2,634

(c) FHL

	Banks	ETFs	MF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δp	0.000**	0.098	0.895***	0.002*	0.002	0.001	0.000	0.000**	0.001***
	(0.000)	(0.064)	(0.066)	(0.001)	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)
Adj. R-sqr.	0.00	0.10	0.90	0.00	0.00	0.00	0.00	0.00	0.00
N. of obs	1,282,001	1,282,001	1,282,001	1,282,001	1,282,001	1,282,001	1,282,001	1,282,001	1,282,001

(d) FNM

	Banks	ETFs	MF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δp	0.008***	0.073***	0.649***	0.015**	0.010***	0.007***	0.039**	0.026***	0.177***
	(0.002)	(0.028)	(0.083)	(0.007)	(0.003)	(0.002)	(0.017)	(0.006)	(0.041)
Adj. R-sqr.	0.01	0.07	0.63	0.01	0.00	0.01	0.04	0.00	0.07
N. of obs	3,186,964	3,186,964	3,186,964	3,186,964	3,186,964	3,186,964	3,186,964	3,186,964	3,186,964

(e) GNM

	Banks	ETFs	MF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δp	0.000***	0.031*	0.955***	0.000**	0.000*	0.000***	0.009	0.000***	0.004***
	(0.000)	(0.018)	(0.022)	(0.000)	(0.000)	(0.000)	(0.007)	(0.000)	(0.001)
Adj. R-sqr.	0.00	0.03	0.96	0.00	0.00	0.00	0.01	0.00	0.00
N. of obs	3,190,886	3,190,886	3,190,886	3,190,886	3,190,886	3,190,886	3,190,886	3,190,886	3,190,886

Table 3: Baseline price variation decomposition: Corporate bonds. This table reports the baseline price variation decomposition based on (2) into contributions from each holder sector for U. S. non-financial corporate bonds. All regressions include security fixed effects, rating and industry fixed effects. Hodrick (1992) standard errors reported in parentheses below point estimates. *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

(a) Investment grade, excluding BBB

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	Outside inv.
Δp	0.000**	0.534***	0.117***	0.000*	0.001***	0.021***	0.003**	0.004***	0.331***
	(0.000)	(0.018)	(0.007)	(0.000)	(0.000)	(0.004)	(0.001)	(0.001)	(0.021)
Adj. R-sqr.	0.00	0.55	0.21	0.00	0.00	0.01	0.00	0.00	0.23
N. of obs	98,852	98,852	98,852	98,852	98,852	98,852	98,852	98,852	98,852

(b) BBB

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	Outside inv.
Δp	0.000*	0.135***	0.074***	0.000**	0.003***	0.046***	0.007***	0.054	0.694***
	(0.000)	(0.016)	(0.007)	(0.000)	(0.000)	(0.004)	(0.001)	(0.041)	(0.034)
Adj. R-sqr.	0.01	0.12	0.06	0.00	0.00	0.01	0.01	0.05	0.53
N. of obs	118,956	118,956	118,956	118,956	118,956	118,956	118,956	118,956	118,956

(c) BB

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	Outside inv.
Δp	0.000**	0.043***	0.298**	0.000*	0.017	0.046	0.015	0.029	0.796***
	(0.000)	(0.008)	(0.137)	(0.000)	(0.011)	(0.037)	(0.011)	(0.019)	(0.056)
Adj. R-sqr.	0.00	0.05	0.26	0.00	0.08	0.04	0.04	0.07	0.64
N. of obs	37,145	37,145	37,145	37,145	37,145	37,145	37,145	37,145	37,145

(d) High yield, excluding BB

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	Outside inv.
Δp	0.000***	0.011***	0.333***	0.000	0.008***	0.005**	0.002**	0.008***	0.698***
	(0.000)	(0.002)	(0.040)	(0.000)	(0.002)	(0.002)	(0.001)	(0.002)	(0.040)
Adj. R-sqr.	0.01	0.01	0.27	0.00	0.02	0.00	0.00	0.01	0.56
N. of obs	52,178	52,178	52,178	52,178	52,178	52,178	52,178	52,178	52,178

Table 4: Price impact of Federal Reserve balance sheet size. This table reports the coefficients from the regression of log price deviations on log deviations in Federal Reserve's total assets by security type. Treasury regressions also include term fixed effects; agency MBS regressions include vintage year fixed effects; corporate bond regressions include rating and industry fixed effects. Hodrick (1992) standard errors reported in parentheses below point estimates. *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

	U. S. Treasuries		Agency MBS			Corporate bonds			
	Bonds	Notes	FHL	FNM	GNM	IG, ex BBB	BBB	BB	HY, ex BB
Δ SOMA	0.05***	0.04**	-0.02	0.03***	-0.03***	-0.00	0.04***	0.11***	0.10***
	(0.00)	(0.02)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Adj. R-sqr.	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.01
N. of obs	9,602	2,634	1,282,001	3,186,964	3,190,886	98,852	118,956	37,145	52,178

Table 5: Contributions to SOMA price impact: U. S. Treasuries and agency MBS. This table reports the decomposition of price impact of changes in the size of the Federal Reserve balance sheet into contributions from each holder sector for U. S. securities. All regressions include security fixed effects. Treasury regressions also include term fixed effects; agency MBS regressions include vintage year fixed effects. Hodrick (1992) standard errors reported in parentheses below point estimates. *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

(a) TSY notes

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δ SOMA	0.003**	0.001	-0.006***	-0.001***	-0.001***	-0.003***	-0.002***	-0.002***	0.340***	-0.223***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.008)
Adj. R-sqr.	0.00	0.00	0.01	0.00	0.01	0.02	0.02	0.01	0.56	0.33
N. of obs	9,602	9,617	9,617	9,617	9,617	9,617	9,617	9,617	9,617	9,617

(b) TSY bonds

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δ SOMA	-0.001	-0.015***	-0.005***	0.000	-0.001***	-0.017***	-0.001***	-0.000	0.466***	-0.275***
	(0.001)	(0.003)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.029)	(0.015)
Adj. R-sqr.	0.00	0.02	0.01	0.00	0.02	0.18	0.04	0.00	0.52	0.41
N. of obs	2,634	2,635	2,635	2,635	2,635	2,635	2,635	2,635	2,635	2,635

(c) FHL

	Banks	ETFs	MF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δ SOMA	-0.002***	0.006	-0.050**	-0.003***	-0.001	-0.001**	-0.000	-0.015***	0.057***
	(0.000)	(0.007)	(0.025)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Adj. R-sqr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
N. of obs	1,282,048	1,282,874	1,282,874	1,282,874	1,282,874	1,282,874	1,282,874	1,282,874	1,282,871

(d) FNM

	Banks	ETFs	MF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δ SOMA	-0.002***	0.001***	-0.004***	0.000	-0.002***	0.000***	-0.001**	-0.026***	0.085***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Adj. R-sqr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03
N. of obs	3,186,969	3,189,827	3,189,827	3,189,827	3,189,827	3,189,827	3,189,827	3,189,827	3,189,824

(e) GNM

	Banks	ETFs	MF	VA	Life	P&C	Oth. eMaxx	SOMA	Outside inv.
Δ SOMA	-0.001***	0.001	-0.025***	0.000***	-0.000**	0.000***	-0.002*	0.001***	0.003***
	(0.000)	(0.001)	(0.004)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)
Adj. R-sqr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N. of obs	3,190,886	3,194,123	3,194,123	3,194,123	3,194,123	3,194,123	3,194,123	3,194,123	3,194,123

Table 6: Contributions to SOMA price impact: Corporate bonds. This table reports the decomposition of price impact of changes in the size of the Federal Reserve balance sheet into contributions from each holder sector for U. S. non-financial corporate bonds. All regressions include security fixed effects, rating and industry fixed effects. Hodrick (1992) standard errors reported in parentheses below point estimates. *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

(a) Investment grade, excluding BBB

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	Outside inv.
Δ SOMA	-0.000***	-0.041***	-0.013***	-0.000***	-0.001***	-0.000	-0.000***	0.000	0.052***
	(0.000)	(0.003)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.002)
Adj. R-sqr.	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02
N. of obs	99,661	99,350	99,350	99,350	99,350	99,350	99,350	99,350	98,855

(b) BBB

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	Outside inv.
Δ SOMA	-0.000***	0.001	-0.006***	0.000	-0.001***	0.005***	-0.001***	-0.000	0.047***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.002)
Adj. R-sqr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
N. of obs	119,861	119,515	119,515	119,515	119,515	119,515	119,515	119,515	118,962

(c) BB

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	Outside inv.
Δ SOMA	0.000	-0.001	-0.004*	0.000**	-0.003***	-0.005***	-0.001***	-0.003***	0.128***
	(0.000)	(0.001)	(0.002)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.006)
Adj. R-sqr.	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.04
N. of obs	37,532	37,329	37,329	37,329	37,329	37,329	37,329	37,329	37,148

(d) High yield, excluding BB

	Banks	ETFs	MF	MMMF	VA	Life	P&C	Oth. eMaxx	Outside inv.
Δ SOMA	0.000	-0.004***	0.003	0.000	-0.005***	-0.003***	-0.001***	-0.004***	0.110***
	(0.000)	(0.001)	(0.003)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.007)
Adj. R-sqr.	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
N. of obs	52,741	52,270	52,270	52,270	52,270	52,270	52,270	52,270	52,191

Table 7: Price impact of Federal Reserve balance sheet size across sub-periods. This table reports the coefficients from the regression of log price deviations on log deviations in Federal Reserve's total assets by security type. "QE1/2/3" is the period from Q1 2009 to Q3 2014; QT1 is the period from Q4 2017 to Q3 2019; QE4 is the period from Q1 2020 to Q1 2022; QT2 is the period from Q2 2022 to Q4 2023; periods without Federal Reserve balance sheet increases or decreases are the omitted category. Treasury regressions also include term fixed effects; agency MBS regressions include vintage year fixed effects; corporate bond regressions include rating and industry fixed effects. Hodrick (1992) standard errors reported in parentheses below point estimates. *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

	U. S. Treasuries		Agency MBS			Corporate bonds			
	Bonds	Notes	FHL	FNM	GNM	IG, ex BBB	BBB	BB	HY, ex BB
Δ SOMA	-0.07***	0.01	-0.43*	0.02***	-0.13***	-0.11***	0.05***	0.22***	0.31***
	(0.02)	(0.04)	(0.25)	(0.00)	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)
QE1/2/3 $\times$ Δ SOMA	0.16***	0.20***	0.35	0.01***	0.15***	0.19***	0.06***	0.02	-0.00
	(0.02)	(0.06)	(0.23)	(0.00)	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)
QT1 $\times$ Δ SOMA	0.03***	-0.23***	0.05	-0.09***	-0.19***	-0.01	0.02***	0.04*	0.07**
	(0.01)	(0.04)	(0.22)	(0.01)	(0.07)	(0.01)	(0.01)	(0.02)	(0.03)
QE4 $\times$ Δ SOMA	0.01	-0.37***	0.34	-0.07***	0.08***	0.10***	0.08***	0.02	-0.06**
	(0.02)	(0.04)	(0.22)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)
QT2 $\times$ Δ SOMA	-0.09***	-0.25***	0.40**	0.03**	-0.01	0.13***	0.11***	0.17***	0.33***
	(0.03)	(0.04)	(0.20)	(0.01)	(0.06)	(0.02)	(0.01)	(0.03)	(0.05)
Adj. R-sqr.	0.13	0.66	0.00	0.02	0.00	0.15	0.19	0.12	0.07
N. of obs	9,602	2,634	1,282,001	3,186,964	3,190,886	98,852	118,956	37,145	52,178

Table 8: Decomposing SOMA contribution. This table reports the decomposition of price impact of changes in the size of the Federal Reserve balance sheet into contributions from each holder sector for U. S. securities. All regressions include security fixed effects. Treasury regressions also include term fixed effects; agency MBS regressions include vintage year fixed effects. Hodrick (1992) standard errors reported in parentheses below point estimates. *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

(a) TSY notes

	SOMA	SOMA allocation	SOMA growth	Outside inv.
Δ SOMA	0.325***	0.064*	0.261***	-0.330***
	(0.032)	(0.033)	(0.017)	(0.025)
QE1/2/3 × Δ SOMA	0.317***	0.184***	0.133***	-0.032
	(0.061)	(0.056)	(0.024)	(0.036)
QT1 × Δ SOMA	0.056***	0.053***	0.003	0.014
	(0.015)	(0.014)	(0.007)	(0.016)
QE4 × Δ SOMA	-0.039	0.013	-0.053**	0.006
	(0.028)	(0.035)	(0.022)	(0.023)
QT2 × Δ SOMA	-0.244***	-0.158***	-0.086***	-0.016
	(0.036)	(0.041)	(0.026)	(0.037)
Adj. R-sqr.	0.61	0.18	0.79	0.38
N. of obs	9,617	9,617	9,617	9,617

(b) TSY bonds

	SOMA	SOMA allocation	SOMA growth	Outside inv.
Δ SOMA	0.502***	0.578***	-0.077*	-0.233**
	(0.124)	(0.141)	(0.044)	(0.093)
QE1/2/3 × Δ SOMA	0.523***	-0.086	0.609***	-0.144
	(0.148)	(0.158)	(0.051)	(0.102)
QT1 × Δ SOMA	-0.278***	-0.247**	-0.031	-0.021
	(0.102)	(0.111)	(0.029)	(0.088)
QE4 × Δ SOMA	-0.427***	-0.885***	0.458***	-0.161*
	(0.117)	(0.138)	(0.047)	(0.087)
QT2 × Δ SOMA	-0.676***	-1.233***	0.558***	0.242***
	(0.114)	(0.136)	(0.053)	(0.093)
Adj. R-sqr.	0.71	0.31	0.91	0.60
N. of obs	2,635	2,635	2,635	2,635

(c) FHL

	SOMA	SOMA allocation	SOMA growth	Outside inv.
Δ SOMA	0.032***	-0.037***	0.069***	-0.007*
	(0.003)	(0.003)	(0.001)	(0.004)
QE1/2/3 × Δ SOMA	-0.050***	-0.001	-0.049***	0.079***
	(0.003)	(0.003)	(0.001)	(0.004)
QT1 × Δ SOMA	0.032***	0.041***	-0.009***	-0.088***
	(0.003)	(0.003)	(0.001)	(0.004)
QE4 × Δ SOMA	0.024***	0.052***	-0.027***	-0.055***
	(0.003)	(0.003)	(0.001)	(0.004)
QT2 × Δ SOMA	0.094***	0.143***	-0.049***	-0.104***
	(0.003)	(0.003)	(0.002)	(0.005)
Adj. R-sqr.	0.02	0.04	0.07	0.06
N. of obs	1,282,874	1,282,874	1,282,874	1,282,871

(d) FNM

	SOMA	SOMA allocation	SOMA growth	Outside inv.
Δ SOMA	-0.013***	-0.116***	0.103***	0.084***
	(0.002)	(0.002)	(0.001)	(0.003)
QE1/2/3 × Δ SOMA	-0.019***	0.049***	-0.067***	0.017***
	(0.002)	(0.002)	(0.001)	(0.003)
QT1 × Δ SOMA	0.065***	0.070***	-0.005***	-0.175***
	(0.002)	(0.003)	(0.001)	(0.003)
QE4 × Δ SOMA	0.083***	0.158***	-0.075***	-0.181***
	(0.002)	(0.003)	(0.001)	(0.003)
QT2 × Δ SOMA	0.179***	0.290***	-0.110***	-0.259***
	(0.003)	(0.003)	(0.001)	(0.004)
Adj. R-sqr.	0.02	0.05	0.11	0.07
N. of obs	3,189,827	3,189,827	3,189,827	3,189,824

(e) GNM

	SOMA	SOMA allocation	SOMA growth	Outside inv.
Δ SOMA	0.000	-0.063***	0.064***	-0.057***
	(0.001)	(0.002)	(0.001)	(0.002)
QE1/2/3 × Δ SOMA	0.002**	0.033***	-0.032***	0.090***
	(0.001)	(0.002)	(0.001)	(0.002)
QT1 × Δ SOMA	0.006***	-0.027***	0.033***	-0.029***
	(0.001)	(0.002)	(0.001)	(0.003)
QE4 × Δ SOMA	0.031***	0.077***	-0.046***	0.002
	(0.001)	(0.002)	(0.001)	(0.003)
QT2 × Δ SOMA	0.059***	0.206***	-0.147***	-0.021***
	(0.002)	(0.004)	(0.003)	(0.005)
Adj. R-sqr.	0.01	0.06	0.07	0.02
N. of obs	3,194,123	3,194,123	3,194,123	3,194,123