What Do $40 Trillion of Portfolio Holdings Say about Monetary Policy Transmission? *

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Abstract

We use granular portfolio holdings data of major U.S. bond investors to study the transmission of monetary policy. When the Fed conducts expansionary monetary policy, mutual funds purchase more bonds due to capital inflows; insurance companies extend portfolio duration to hedge liabilities; and banks perform both actions to accommodate deposit inflows and offset the shortening duration of mortgages. The additional investor demand serves as a "helping hand," amplifying the Fed's impact on long-term yields. The excess demand is primarily absorbed through new issuance by the Department of the Treasury, corporations, and mortgage borrowers, with primary dealers playing a more limited role. We use an asset-demand system to quantify the contributions of different investors. Over the past 20 years, the flow-induced demand channel has strengthened, but net issuance has become even more elastic. As a result, bond yield sensitivity to monetary policy has undergone a secular decline, particularly at low frequencies.

Keywords: monetary policy, market clearing, demand system, state dependency

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1 Introduction

The Federal Reserve exerts a surprisingly large influence on long-term interest rates. When the Fed changes short-term interest rates, long-term rates respond much more strongly than implied by the expected trajectory of future short rates alone.[1] Similarly, unconventional monetary policies such as quantitative easing (QE) significantly impact long-term interest rates, in contrast to the predictions of conventional macro theory.[2]

A growing consensus is that the Fed, through setting the short-term interest rate or purchasing long-term assets, influences the risk premium component of long-term interest rates. Yet, an important open question is how the Fed affects risk pricing in the first place. Casual observers and financial news often note that investors closely track monetary policy and adjust their portfolios in response, but the mechanisms driving these shifts are not well understood. How does monetary policy influence investors' portfolio holdings? Who absorbs these shifts in investor demand and ensures market clearing? To what extent do these demand and supply dynamics shape equilibrium bond yields, particularly their sensitivity to monetary policy?

To answer these questions, we assemble a comprehensive dataset of granular portfolio holdings by the largest bond investors: mutual funds, insurance companies, banks, primary dealers, and the Federal Reserve. The data capture quarterly snapshots of investor positions across major bond classes—Treasury notes and bonds, agency mortgage-backed securities (MBS), and corporate bonds—resulting in 546 million portfolio-level observations from

[1] Gürkaynak, Sack, and Swanson (2005), Hanson and Stein (2015) and Nakamura and Steinsson (2018) show that monetary policy shocks have large impacts on long-term Treasury yields, employing different definitions of policy shocks and different windows around FOMC announcements. Gertler and Karadi (2015) and Brooks, Katz, and Lustig (2018) find additional delayed responses by examining the impulse responses of long-term Treasury and corporate yields to monetary policy shocks. Hanson, Lucca, and Wright (2021) notes the decay in long-term yield sensitivity at lower frequency. Nagel and Xu (2024) suggests that yield movement explain the stock sensitivity to monetary policy.

[2] See Greenwood, Hanson, and Vayanos (2023). For evidence of QE impacts on long-term interest rates, see Krishnamurthy and Vissing-Jorgensen (2011); D'Amico, English, López-Salido, and Nelson (2012); Swanson (2021); Selgrad (2023); Haddad, Moreira, and Muir (2024).

20,595 investors between 2003 and 2022, representing nearly $40 trillion in bond holdings by the end of our sample period.

We begin by documenting a set of new stylized facts regarding investor portfolio adjustments following conventional and unconventional monetary policy actions. After a 100 bps cut in the short-term interest rate, mutual funds and banks expand their bond holdings by 0.16% and 0.24% of the total market size in the same quarter, acting as a "helping hand" that amplifies the Fed's intervention. This holdings expansion is more salient at an annual horizon, at 0.46% for mutual funds and 0.43% for banks. This effect arises because both institutions experience significant capital inflows from households, expanding their balance sheets by 8–10%.

When mutual funds and banks purchase more bonds following a rate cut, how does the market clear? The existing literature emphasizes primary dealers' role as liquidity providers,[3] but their capacity is insufficient to accommodate all additional demand. Specifically, when mutual funds and banks collectively purchase 0.34% of Treasury bonds outstanding, 0.56% of MBS outstanding, and 0.27% of corporate bonds outstanding during monetary easing, less than 0.08% is absorbed by primary dealers. Instead, most of the demand is met through new issuance by the Treasury Department, mortgage borrowers, and corporations: they issue more or repurchase fewer bonds, totaling 0.40% Treasury bonds, 0.46% MBS, and 0.47% corporate bonds—nearly matching the purchases from mutual funds and banks. Insurance companies, facing stable capital flows that are orthogonal to monetary policy, also slightly decrease Treasury and corporate holdings following a rate cut.

Investors adjust not only the size of their portfolio holdings but also their composition. Following a rate cut, banks increase the duration of their Treasury bond holdings, as heightened prepayment probabilities shorten the duration of MBS. Insurance companies extend their portfolio duration to hedge against increased liability duration driven by convexity effects.

[3]See for instance, the class of preferred habitat models following Vayanos and Vila (2021).

Regarding credit risk, mutual funds shift toward holding more lower—rated bonds, a pattern also observed—though to a lesser degree—among insurers. These portfolio patterns have important implications for the pricing of duration and credit risks in the cross-section of bonds.

A similar set of portfolio adjustments occurs under unconventional monetary policy, where the Fed directly purchases Treasury bonds and MBS. Mutual funds and banks, once again experiencing capital inflows, increase their purchases of Treasuries. However, unlike in conventional policy easing, where banks purchase bonds across the board, they become net sellers of MBS during quantitative easing.

Just as with conventional monetary easing, purchases by the Fed, mutual funds, and banks are primarily met by new issuance rather than by investors selling existing assets. When the Fed conducts QE, Treasury issuance rises by 1.13% of outstanding bonds, nearly matching the combined purchases by the Fed and mutual funds, which total 1.09% of outstanding Treasury bonds. Corporate bonds and MBS follow a similar pattern, with issuance playing a dominant role in absorbing investor demand, and primary dealers having only a limited impact, particularly at annual frequencies. Finally, the effects of unconventional monetary policy on portfolio characteristics also parallel those observed under conventional monetary policy.

Informed by these stylized facts, we develop an asset demand framework to quantify the contributions from various investors as well as net issuance to equilibrium bond yields. In the model, investors exhibit heterogeneous preferences for bond characteristics such as credit rating and duration, reflecting their investment mandates and regulatory constraints. Policymakers set short-term rates through conventional monetary policy and affect the supply of long-term bonds via quantitative easing or tightening. The various transmission channels proposed in the literature are evaluated by counterfactually altering the relevant demand and supply parameters.

In order to capture the complex portfolio substitution behaviors induced by monetary policy, we depart from the existing logit or nested logit demand structures that face important limitations. For example, the logit demand model assumes that, in response to changes in asset prices or characteristics, such as monetary policy-induced MBS duration shortening, investors substitute proportionally across all other assets within their portfolios. We use insights from the industrial organization literature (Berry, Levinsohn, and Pakes, 1995) and introduce random coefficients into the asset demand framework. This modeling technique relaxes the proportionality assumption and enables us to capture heterogeneous cross-elasticities. As a result, investors in our framework exhibit stronger substitutability between bonds with more similar credit ratings and duration, which is essential for transmission channels such as MBS convexity (Hanson, 2014).

We use our estimated demand system to quantify the contribution of different investors in the transmission of monetary policy to long-term yields. To do so, we turn on one transmission channel at a time and calculate the market-clearing bond yields, attributing the yield changes to that channel. Our quantification shows that mutual fund flows, bank deposit flows, and changes in insurer demand for duration are the top amplifiers of bond yield sensitivity to monetary policy. The estimated model also reveals significant spillover effects across bond classes. For instance, monetary easing shortens the duration of MBS and other callable bonds, increasing demand for long-term Treasuries and corporate bonds among investors seeking to maintain duration targets. This channel further amplifies the sensitivity of long-term yields to monetary policy. These findings underscore the importance of analyzing different bond classes within a unified demand framework.

The estimated model generates heterogeneous behavior across investors observed in the data. For example, while mutual funds and banks increase their demand for high-credit-risk bonds during monetary easing, insurance companies do the opposite. Such heterogeneity is difficult to extract from market-wide prices but can be better analyzed through a framework like ours,

which utilizes granular portfolio holdings data. To understand the importance of investor heterogeneity, we simulate how monetary transmission would change under different scenarios of investor composition, such as the rise of mutual funds relative to banks and insurance companies.

The estimated model also shows that the supply side is quite elastic. Net issuance by the Treasury Department, corporations, and mortgage borrowers largely dampens the effects of investor demand. Our results provide an explanation for the puzzling difference in yield sensitivity at high frequency versus low frequency. According to our framework, if the amount outstanding is held constant, low-frequency bond yield sensitivities would be as large as the high-frequency sensitivities documented in the literature.

Our structural framework further unveils important dynamics over time. There is a secular rise in the size of bond mutual funds compared to other investors (Ma, Xiao, and Zeng, 2025). Consistent with this trend, we find that the amplification effect of mutual fund flows on yield sensitivity to monetary policy has increased over time. Changes in insurer demand for duration are stronger when interest rates are low. The convexity of callable bonds, such as MBS, which reflects the historical path of monetary policy, determines their duration sensitivity to future policy changes. Net issuance, particularly by corporations and mortgage borrowers, has become more elastic over time. In the most recent monetary tightening episode from 2021 to 2023, net issuance fell by almost twice as much as during the tightening episode from 2003 to 2006, conditional on per unit change in the short-term rate. Our results shed light on the decline of bond yield sensitivity to monetary policy, particularly at low frequencies. Rather than being a sign of weakened monetary transmission, we show that the declining yield sensitivity reflects the heightened responses from the real sector, which should be a key part of policymakers' objective function.

Finally, we use our framework to analyze the transmission of unconventional monetary policies such as quantitative easing (QE). We find that investor demand channels amplify the

direct effects from the Fed's purchases by a factor of two. Similar to conventional policies, QE is associated with significant inflows to mutual funds and banks, as well as increases in demand for duration, particularly from insurance companies, both of which further push down bond yields. Net issuance increases bond yields and almost entirely neutralizes the combined effects of the Fed and other investors. The dampening effects of net issuance help explain why the effects of QE are concentrated on announcement dates but revert substantially over time.

The transmission of monetary policy to bond markets has been widely studied, with existing literature identifying several key mechanisms. Some studies find that lower interest rates encourage institutional reaching for yield, leading investors to shift toward riskier or longer-duration bonds (Choi and Kronlund, 2018; Anadu, Bohn, Lu, Pritsker, and Zlate, 2019), while others show that regulatory constraints may limit such behavior (Li, 2024). Another major channel is duration hedging: as falling rates reduce the effective duration of mortgages, investors rebalance into long-term non-callable bonds, compressing yields (Hanson, 2014; Hanson et al., 2021). Liability-driven investors, such as insurance companies and pension funds, also adjust their portfolios to maintain asset-liability duration matching, further affecting bond yields (Domanski, Shin, and Sushko, 2017; Ozdagli and Wang, 2019; Greenwood and Vissing-Jorgensen, 2018; Jansen, 2023). Additionally, extrapolative mutual fund flows amplify bond yield sensitivity by reinforcing investor demand following rate cuts (Brooks et al., 2018; Hanson et al., 2021; Fang, 2023; Darmouni, Siani, and Xiao, 2024).

Our paper advances this literature by compiling a comprehensive dataset of portfolio holdings across the near-universe of bond investors, allowing us to use a quantity-based approach to empirically quantify the relative importance of these channels. Using market clearing as the guiding principle, we assess how monetary policy reshapes portfolio allocation across different investor types, the term structure, and the credit spectrum. Our findings highlight the role of bond issuance and redemption dynamics in absorbing monetary shocks, underscoring that

understanding monetary transmission requires going beyond yield changes and examining shifts in bond supply by the real sector.

This paper contributes to the growing literature that employs asset demand systems and granular portfolio holdings to study asset pricing (Koijen and Yogo, 2019, 2020; Koijen, Koulischer, Nguyen, and Yogo, 2021; Bretscher, Schmid, Sen, and Sharma, 2021; Fang, Hardy, and Lewis, 2024; Darmouni et al., 2024; Azarmsa and Davis, 2024; Jansen, Li, and Schmid, 2024; Chaudhary, Fu, and Zhou, 2024). Our primary contribution is extending existing logit and nested logit frameworks by introducing a random-coefficient demand model, drawing from the industrial organization literature (Berry et al., 1995). This flexibility is essential for accurately modeling key transmission channels, such as MBS convexity effects (Hanson, 2014), and provides a more nuanced view of how monetary policy reshapes bond market allocations.

Second, prior studies have typically focused on broad asset classes (Koijen and Yogo, 2020; Jiang, Richmond, and Zhang, 2022) or one specific segment of the fixed income market such as Treasury bonds (Jansen et al., 2024) or corporate bonds (Bretscher et al., 2021; Darmouni et al., 2024). In comparison, we construct a comprehensive security-level dataset that covers Treasury, corporate and MBS securities, which together virtually span the entire U.S. bond market. This dataset allows us to reveal transmission dynamics not only within but also across individual market segments, such as the substitution between Treasury bonds and MBS with varying duration.

2 Data

2.1 Portfolio holdings

The core of our analysis relies on a comprehensive dataset of portfolio holdings. We focus on five types of bond investors for which we have granular holdings data: mutual funds and ETFs, insurance companies, banks, primary dealers, and the Federal Reserve. Data on mutual fund holdings come from Morningstar Direct. We include both U.S.-domiciled funds and foreign funds that focus on U.S. assets (indicated by base currency). We restrict to funds whose broad investment category is fixed income or allocation and therefore make meaningful investment in bonds.

Data on insurance company general account holdings come from NAIC statutory filings, Schedule D. Quarterly holdings are calculated using annual holdings (Part 1) and daily transactions (Part 3 and 4). We focus on those that sell life insurance or P&C insurance and exclude health insurers, which have small bond holdings.

Data on bank holdings come from call reports. Each bank reports holdings across bond classes – Treasury, agency obligations, municipal, MBS, ABS, and others – and by maturity buckets – less than 1Y, 1-3Y, 3-5Y, 5-15Y, 15Y or above. We map bank holdings to the more granular security level according to amount outstanding.

Data on primary dealer holdings come from New York Fed's Primary Dealer Statistics. The data are aggregated across all primary dealers. Similar to banks, holdings are reported by bond classes and by maturity buckets – less than 2Y, 2-3Y, 3-6Y, 6-7Y, 7-11Y, 11-21Y, 21Y or above.

Data on the Fed holdings come from System Open Market Account (SOMA) and Secondary Market Corporate Credit Facility (SMCCF). SOMA contains weekly holdings of Treasury

and agency securities at the CUSIP level, from 2003 to present. SMCCF contains corporate bond holdings and transactions since 2020. Primary Market Corporate Credit Facility (PMCCF) was never actually used.

2.2 Bond securities

We collect data on three classes of bonds, which together span virtually the entire U.S. taxable bond market: Treasury bonds, corporate bonds, and mortgage-backed securities (MBS).[4] As they share similar characteristics and similar investor base, the yields of these three bond classes are tightly linked, and they should be jointly determined in equilibrium. Having a diverse set of bonds is essential for us to capture some of the transmission channels that would have been silent otherwise (e.g. MBS convexity). One key consideration is the availability of data on amount outstanding, which is required to derive equilibrium through market clearing — this why we exclude, for example, foreign bonds and private (non-144A) bonds.

Data on Treasury bonds come from CRSP. We focus on Treasury notes and Treasury bonds and treat Treasury bills as cash. We exclude flower bonds. Data on corporate bonds (including agency direct obligations) come from Mergent FISD (for characteristics) and TRACE (for pricing). We include private placement bonds under Rule 144A. We exclude convertible bonds, equity-linked bonds, preferred securities and puttable bonds. Data on agency MBS come from Refinitiv. We focus on agency pools and TBAs and exclude CMOs. We exclude foreign bonds and private (non-144A) bonds because they lack data on amount outstanding, trading, or other characteristics that are essential for our demand system analysis.

We take the median credit rating from S&P, Moody's, and Fitch. All Treasury bonds are AAA-rated, all agency securities are rated AA or higher, and most of corporate bonds are

[4]We treat agency direct obligations as corporate bonds with high credit ratings. Our main results are similar if we treat agency direct obligations as a stand-alone bond class.

rated. We convert letter rating to a numeric scale from 0 (AAA) to 6 (CCC or lower). Bonds without credit rating are dropped. Our main results are robust to treating unrated bonds as having the lowest rating.

We measure duration by weighted-average life, that is, the weighted average of years to each coupon or principal payment. The calculation is straightforward for non-callable bonds. For callable bonds such as MBS, we estimate duration by simulation. Specifically, for given values of macroeconomic variables such as the short-term rate, we simulate a large set of future scenarios. For each scenario, we predict prepayments based on their historical conditional means. We take the average of realized duration across scenarios.

Bid and ask quotes are directly available for Treasury bonds through CRSP. For agency MBS, we randomly sample 10,000 CUSIPs, hand-collect their historical bid and ask quotes from Refinitiv, and assume that they represent their respective cohorts (i.e., those with the same origination year, coupon, and term). For corporate bonds, the convention is to calculate bid-ask spreads using trades. Specifically, for each bond on each date, we calculate the bid price as the average price of dealer purchases from customers and the ask price as the average price of dealer sales to customers.

The timings of early redemption can be inaccurate for corporate bonds, so we cross-check with firm-level total bond outstanding from Capital IQ and make manual corrections. For agency MBS, we randomly sample 10,000 CUSIPs, hand collect their historical amount outstanding (factor history) from Refinitiv, and assume that they represent their respective cohorts (i.e. those with the same origination year, coupon and term). For resecuritizations, such as Treasury strips and agency megas, we ensure not to double count them when calculating the total amount outstanding.

Figure 1 shows aggregate holdings for each investor type. It confirms that the three bond classes we consider capture the majority of these bond investors' holdings. Figure 2 shows

aggregate ownership of each bond class. It confirms that the four investors we consider capture the majority of the ownership of these bonds.

3 Stylized Facts on Portfolio Adjustments After Monetary Policy Shifts

In this section, we present several stylized facts on how investors' portfolios change in response to conventional and unconventional monetary policy. For simplicity, we categorize investors at the sector level: mutual funds, insurance companies, banks, primary dealers, and the Federal Reserve. The remaining investors that are not in our data are labeled as the residual investor. In addition to analyzing investor behavior, we also examine net issuance of Treasuries, MBS, and corporate bonds. By market clearing, the sum of purchases (including repurchases by bond issuers) must equal the sum of sales (including new bond issuance).

We run the following quarterly time series regression for each investor sector and separately for Treasuries, MBS, and corporate bonds:

$$\Delta q_t = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \epsilon_t \tag{1}$$

Δq denotes the quarterly change in par amount held by the investor sector, scaled by the amount outstanding. Δr^{1Y} denotes the quarterly change in the one-year Treasury rate as a proxy for the action of conventional monetary policy.[5] Δq denotes quarterly purchases of Treasuries and MBS by the Fed, scaled by the outstanding amount of Treasuries and MBS combined.

We focus on active purchases and sales of bonds and exclude natural redemption at maturity.

[5]We later use alternative measures such as changes in the Fed Funds rate target and monetary surprises in the robustness.

We also exclude redemption through the exercising of call or prepayment options. In these cases, investors are forced to sell to bond issuers.

3.1 Changes in holding amounts

We first describe how portfolios change following conventional monetary policy in Panel A of Figure 3. We plot $-\beta_1$, which can be interpreted as portfolio changes facing a 100 bps decline in the one-year Treasury rate. Starting at the top of the graph, mutual funds increase holdings across all classes of bonds. Specifically, their Treasury, MBS, and corporate holdings increase by 0.13%, 0.19%, and 0.26% of the total amount outstanding in the same quarter. This is consistent with the fact that bond mutual funds tend to experience large inflows of return-chasing capital when interest rates decline (Brooks et al., 2018; Fang, 2023). As shown in Panel A of Figure˜**??**{figure:flows}, bond mutual funds experience significant inflows following a 100 bps rate cut, with about 2% of their AUM one quarter, increasing to 7% after four quarters. Figure A1 shows that this relationship between rate declines and mutual fund purchases is even stronger at an annual frequency, consistent with the fact that mutual fund flows chase returns at a low frequency (Barber, Huang, and Odean, 2016).

Similar to mutual funds, banks experience large inflows of checking and savings deposits (Drechsler, Savov, and Schnabl, 2017; Drechsler, Savov, Schnabl, and Supera, 2024). As shown in Panel A of Figure˜**??**{figure:flows}, banks experience significant inflows following a 100 bps rate cut, with about 3% of their AUM one quarter, rising to 8% after four quarters. Figure 3 shows that banks primarily invest the deposit inflows in Treasury bonds and MBS. In response to a 100 bps rate drop, banks purchase 0.21% of Treasury bonds and 0.37% of MBS. Banks also increase corporate bond holdings, but the size is minimal compared to the total corporate bonds outstanding. Figure A1 shows that the relationship between rate declines and bank purchases is even stronger at an annual frequency, reflecting the persistent

nature of deposit flows.

In contrast to mutual funds and banks, insurance companies decrease their Treasury and corporate bond holdings. As shown in Figure 6, capital flows to insurers do not correlate with monetary policy because they are primarily driven by the purchase of insurance policies, which depend more on long-term demographic and economic factors rather than short-term interest rate changes. In response to rate declines, they actually reduce their Treasury and corporate holdings, suggesting that they act as liquidity providers for mutual funds and banks.

Mutual funds and banks together purchase 0.34% of Treasury bonds, 0.27% of corporate bonds, and 0.58% of MBS in response to a 100 bps rate drop. Who are the sellers, so that the market clears? The existing literature emphasizes the primary dealers' role as liquidity providers,[6] Surprisingly, primary dealers only supply a small fraction of the bond purchases by mutual funds and banks. In response to a 100 bps rate drop, primary dealers supply Treasury bonds and MBS, amounting to 0.10% and 0.08% of the amount outstanding, respectively. Interestingly, similar to mutual funds, primary dealers are net purchasers of corporate bonds, acquiring 0.07% of the market. Figure A1 shows that primary dealers' portfolio changes are even smaller at an annual frequency. Although primary dealers are pivotal in intermediating bond transactions by matching buyers and sellers, they do not seem to absorb demand and supply imbalances at quarterly or annual frequencies. One possible explanation is that the size of the primary dealer sector is too small in comparison to mutual funds, banks, and insurers. For instance, primary dealers only hold 1% of the $20 trillion Treasury market. In episodes where all investors trade in the same direction, primary dealers may find it impossible to meet the entire demand.

If the primary dealers do not accommodate the majority of investor demand, who takes the other side? The accounting identity that purchases must equal the sum of sales and issuance

[6]See for instance, the class of preferred habitat models following Vayanos and Vila (2021).

has to hold after all. It turns out that most of the demand is met through new issuance by the Treasury Department, mortgage borrowers, and corporations. When the one-year Treasury rate declines, the Treasury Department, mortgage borrowers, and corporations issue more bonds (or repurchase less), at 0.40%, 0.46%, and 0.47% of the amount outstanding. The magnitude is comparable to the total purchases by mutual funds and banks. It is worth emphasizing that the results here are not mechanically driven by bond issuers redeeming bonds from investors at maturity or through call or prepayment options, which we carefully exclude.

There are several ways to interpret these stylized facts. One interpretation is demand-driven: when the Fed cuts rates, capital flows into intermediaries such as mutual funds and banks, which purchase more bonds, driving up bond prices and stimulating issuance. Another interpretation is supply-driven: lower rates make borrowing cheaper, prompting mortgage borrowers and corporations to issue more debt. Additionally, the Treasury Department tends to increase bond issuance, as monetary easing often coincides with fiscal expansion. In equilibrium, investors such as mutual funds and banks must absorb these assets. In reality, both channels may be at work. We will decompose the contributions of these various channels in Section 4.

3.2 Changes in portfolio characteristics

After examining portfolio holding amounts, we turn to changes in portfolio characteristics. We run a similar quarterly time series regression for each investor group, separately for Treasury bonds, corporate bonds and MBS:

$$\Delta x_t = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 q_t^{FED} + \epsilon_t \tag{2}$$

Δx denotes quarterly change in the weighted average of either credit rating (AAA = 0, CCC = 6) or option-adjusted duration across all bonds in the portfolio. Δr^{1Y} denotes quarterly change in the one-year Treasury rate. Δq^{FED} denotes quarterly change in the Fed's purchases of Treasuries and MBS, scaled by the outstanding amount of Treasuries and MBS combined. In addition to investor holdings, we also analyze changes in the characteristics of all bonds outstanding, i.e. the market, which represents the weighted average of portfolio changes across all investors.

Results on changes in credit rating are shown in Panel B of Figure 3. In response to a 100 bps rate cut, the average credit rating of all corporate bonds outstanding in the market deteriorates by 0.024 of a letter grade. Relative to this market average, mutual funds' credit rating deteriorates more, by 0.045, consistent with the reaching-for-yield behavior documented in Choi and Kronlund (2018). In contrast, the average credit rating of insurers' bond holdings improves by 0.005, consistent with the motive to preserve regulatory capital due to the increase of unhedged insurance liabilities when rates decline (Li, 2024). The economic magnitude may seem small, but it reflects a change in the average portfolio rating. For this shift to occur, the credit ratings of newly purchased bonds must differ significantly from those in existing portfolios.

Results on changes in duration are shown in Panel C of Figure 3. The most salient result is that the option-adjusted duration of MBS declines substantially, by 0.8 years, in response to a 100 bps rate drop. This is known as mortgage convexity (Hanson, 2014) and can be explained by the increased propensity of households to refinance their mortgages at lower interest rates. This effect is largely homogeneous across investor groups, as it impacts the existing bonds in portfolios rather than arising from newly purchased bonds. The exception is the Fed, which primarily purchases newly issued MBS, resulting in an MBS portfolio that differs significantly from those of other investors. In contrast, the effective duration of Treasury and corporate bonds remains the same because almost all Treasury bonds are non-

callable, and most corporate bonds are either not callable or only callable with a make-whole provision.

While the duration of their MBS holdings declines, most investors increase the duration of their Treasury and corporate bond holdings. For example, following a 100 bps rate drop, the duration of banks' Treasury and corporate bonds increases by 0.06 years, which is substantial given the size of banks' portfolios. This is consistent with the evidence that investors have duration targets and actively adjust their bond holdings in response to duration shocks in order to stay on those targets.

Of all the investors we consider, insurance companies are the most aggressive in increasing the duration of their bond holdings. This is because, in addition to hedging the duration decline of MBS holdings, insurers also need to hedge the duration increase of their long-term liabilities, which also feature convexity (Domanski et al., 2017). As a result, in response to a 100 bps rate decline, the duration of insurers' Treasury bonds (corporate bonds) increases by 0.17 (0.11) years, or 7 (4) times the market average increase.

Due to the simultaneity of conventional and unconventional monetary policy, the Fed purchases more Treasury bonds and MBS that are typically newly issued. As a result, the Fed's portfolio duration increases significantly more—or decreases significantly less—relative to the market.

3.3 Unconventional monetary policy

Portfolio responses to unconventional Fed policies — direct purchases or sales of Treasury bonds and MBS — are given by β_2 of Equation 1. Results are shown in Panel A of Figure 4. The patterns are very similar to those observed for conventional monetary policy. As shown in Panel A of Figure˜**??**{figure:flows}, bond mutual funds once again receive notable inflows

in response to QE, reaching about 1% of their AUM one quarter after the Fed purchases 1% of the bond market and rising to 1.5% after four quarters. This pattern is again consistent with the idea that fund investors chase positive returns resulted from QE. Given the inflows, bond funds increase their purchases of Treasury bonds, corporate bonds, and MBS by 0.09%, 0.08% and 0.06%, respectively.

Banks also receive inflows of about 1% in a quarter and 2% in four quarters after the Fed purchases 1% of the bond market, as shown in Panel A of Figure˜**??**{figure:flows}. These deposit inflows may originate from non-banks that sell assets to the Fed. Facing the inflows, banks purchase Treasuries by 0.08% of the total bond market. These additional purchases act as a "helping hand" that amplifies the Fed's purchase programs.

From whom do the Fed and other investors buy the bonds? Insurance companies and banks appear to be net sellers of MBS, supplying 0.11% of MBS following 1% of Fed purchases. This is different from conventional policy easing, where banks increase purchases of bonds across the board. One explanation for this difference is that when the Fed purchases assets, it simultaneously creates reserves, which can only be held by banks. If the reserves created by the central bank exceed deposit inflows, banks may face an imbalance where they hold excess reserves without a corresponding increase in deposits. In equilibrium, banks might need to adjust their balance sheets by selling other assets.

The majority of the supply once again comes from bond issuers—namely, the Treasury Department, mortgage borrowers, and corporations. The majority of the supply once again comes from bond issuers—namely, the Treasury Department, mortgage borrowers, and corporations. Following a 1% increase in Fed purchases, net issuance responds as follows: Treasuries increase by 1.13%, MBS by 0.53%, and corporate bonds by 0.31%. In contrast, primary dealers contribute only 0.10% of Treasuries and 0.01% of MBS to the supply, while they actually purchase 0.05% of corporate bonds. The patterns are more salient for annual frequency, shown in Figure A2.

Finally, we examine how portfolio characteristics change following unconventional monetary policies. Changes in portfolio characteristics are also similar to those associated with conventional monetary policy. When the Fed purchases bonds, mutual funds increase their credit risk exposure, while insurance companies do the opposite. The effective duration of MBS declines, while the duration of Treasury and corporate bonds increases for mutual funds and insurance companies, with a particularly large effect on the latter. Interestingly, unlike in conventional monetary policy, where banks lengthen the duration of Treasury and corporate bonds to counteract the decline in MBS duration, under quantitative easing, banks instead shorten the duration of their Treasury and corporate bond holdings.

3.4 Understanding net issuance

In the stylized facts above, net issuance appears to be the primary counterparty to net purchases by the Fed and other investors. While it is expected that mortgage borrowers and corporations adjust their supply in response to price signals, it is surprising that the Treasury Department exhibits such flexibility. After all, conventional wisdom suggests that Treasury bond issuance follows a fixed schedule driven by fiscal policy, implying that the supply of government bonds should be largely inelastic to market price fluctuations.

One possible explanation for the correlation between Fed purchases and Treasury issuance is the influence of omitted variables that drive both net issuance and Fed purchases. For instance, during periods of adverse economic shocks, both expansionary monetary and fiscal policies are typically implemented, creating a mechanical correlation between Fed purchases and Treasury issuance.

To better understand the behavior of the Treasury supply, we run the following panel re-

gression using maturity bucket-quarter observations for each group of investors:

$$\Delta q_{m,t} = \alpha + \beta \Delta q_{m,t}^{FED} + \gamma_m + \gamma_t + \epsilon_{m,t} \tag{3}$$

$\Delta q_{m,t}$ denotes quarterly net issuance of a certain maturity bucket of bonds. $\Delta q_{m,t}^{FED}$ denotes quarterly Fed net purchases of Treasury bonds in the same maturity bucket. γ_m and γ_t correspond to maturity bucket fixed effects and time fixed effects, respectively. We follow the New York Fed's Primary Dealer Statistics for maturity bucket designations: less than 2 years, 2–3 years, 3–6 years, 6–7 years, 7–11 years, 11–21 years, and 21 years or longer.[7] The inclusion of time fixed effects removes time-series variation in macroeconomic conditions that might simultaneously influence monetary and fiscal policy decisions. Consequently, the regression primarily identifies the correlation between net issuance and Fed purchases in the cross-section of bond maturity buckets.

Results are shown in Panel A of Figure 5. In a given quarter, when the Fed purchases 1% of a certain maturity bucket of Treasury bonds, the Treasury Department issues 0.894% of bonds in that particular maturity bucket. Banks accommodate 0.071% of the Fed's purchases. Net purchases by primary dealers and other investors, including the residual sector, are negligible. Figure A3 shows that the pattern is similar at an annual frequency.

These fixed-effect regressions provide further evidence that when the Fed conducts QE and purchases Treasury bonds, it primarily absorbs new issuance from the Treasury Department, while the holdings of other investors remain largely unchanged. This finding raises questions about the overall economic significance of the portfolio rebalancing channel of quantitative

[7] Measuring net purchases at the maturity bucket level presents technical challenges. Since bond maturity naturally shortens over time, bonds may migrate between maturity buckets over quarterly or annual horizons, altering holdings within a bucket even without actual trades. To address this, we track changes in holdings on a bond-by-bond basis and aggregate these changes based on the bond's maturity bucket at the end of the period. This approach ensures that our measure captures only actual changes in holdings while excluding mechanical re-classifications. Unfortunately, this method is infeasible for banks and primary dealers, who report holdings only at the maturity bucket level. Nevertheless, we will show that our results remain consistent for investors with bond-level data, regardless of whether we use raw changes in maturity bucket-level holdings.

easing, which posits that the Fed purchases Treasuries from investors, inducing them to reallocate into riskier corporate bonds with similar maturities. Instead, the results suggest that the Treasury Department plays a more important role in adjusting to the Fed's purchases and sales in the Treasury market.

So far, we have shown that Treasury net issuance closely matches the Fed's purchases in terms of overall economic magnitude, while other investors' portfolios remain largely unchanged. There are two possible interpretations of this pattern. First, the Treasury Department may issue bonds according to a fixed schedule dictated by fiscal policy, while the Fed strategically buys or sells bonds in maturity buckets where issuance occurs. Second, the Fed may conduct unconventional monetary policy based on an exogenous rule, while the Treasury Department strategically adjusts its bond issuance in response to the Fed's demand.

To distinguish between these two interpretations, we examine a scenario where large shocks to Treasury demand originate not from the Fed but from the mechanical buying and selling of passive bond mutual funds. Specifically, we run the same fixed-effect regression, replacing the Fed's purchases with the net purchases of passive mutual funds, following Sammon and Shim (2024):

$$\Delta q_{m,t} = \alpha + \beta \Delta \hat{q}_{m,t}^{PASSIVE} + \gamma_m + \gamma_t + \epsilon_{m,t} \tag{4}$$

$\Delta \hat{q}_{m,t}^{PASSIVE}$ is the flow-induced passive purchases, i.e. purchases made by passive funds if they proportionally scale their existing bond holdings in response to flows. The idea is that net purchases by passive mutual funds are supposed to be particularly inelastic, as these funds are mandated to mechanically translate inflows or outflows into purchases or sales of the index constituents. Using the actual purchases by passive funds instead of the flow-induced passive purchases yields very similar results.

Results are shown in Panel B of Figure 5. When passive funds purchase 1% of a maturity bucket of Treasury bonds, the Treasury Department actually issues 0.75% more bonds in the

same maturity bucket in which passive bond mutual funds buy. This result suggests that the supply of Treasuries is indeed quite elastic and responds to changes in market demand.

Finally, we also examine what happens if passive funds purchase corporate bonds using the same specification as in equation 4, as a comparison. In defining buckets for corporate bonds, we again follow the New York Fed's Primary Dealer Statistics: less than 1 year, 1-5 years, 5-15 years, and more than 15 years, interacted with investment-grade vs. below-investment-grade. Similar to the Treasury results, issuance by corporations accommodate most of these purchases. Again, other investors and primary dealers play a small role.

4 Demand System Framework

The reduced-form analysis above reveals several key stylized facts about portfolio adjustments following monetary policy actions:

1. **Mutual funds and banks act as a "helping hand" to the Fed**—when the Fed eases monetary policy by lowering short-term rates or purchasing safe assets, funds and banks experience capital inflows and increase their bond holdings.

2. **Insurance companies primarily adjust portfolio composition rather than overall portfolio size** to manage duration.

3. **Bond net issuance is highly elastic**, not only for private-sector entities such as mortgage borrowers and corporations but also for the Treasury Department.

This section develops a demand system in the style of Koijen and Yogo (2019) to jointly analyze both prices and quantities under the principle of market clearing. The objective is to address key questions that are difficult to study using reduced-form methods. First, what are the demand and supply elasticities of major market participants? Second, how

do the actions of different players influence equilibrium bond yields and the transmission of monetary policy? Third, given the structural changes in the financial system, how has the transmission of monetary policy in the bond market evolved?

The demand system framework is particularly suited to analyzing bonds for several reasons. First, many bond investors have a direct preference for certain bond characteristics. For example, life insurance companies prefer long-duration bonds that match the long duration of their insurance liabilities. Moreover, demand can be heterogeneous—a short-term bond mutual fund can have drastically different preferences for duration than a life insurer does. Lastly, many bond investors engage in buy-and-hold strategies and can be quite price inelastic due to regulatory reasons (e.g. Fang, 2024), so quantity changes (e.g., fund flows) can have large price impacts.

One methodological innovation we introduce is relaxing the proportional substitution property of the logit demand model in Koijen and Yogo (2019) by incorporating random demand coefficients, following Berry et al. (1995). This refinement is crucial for capturing some of the monetary transmission channels in our context.

To illustrate, consider an exogenous reduction in the supply of long-duration MBS due to a rate cut, prompting banks to seek substitutes. Under the standard logit demand framework, banks would allocate funds proportionally across their portfolio. However, in reality, banks may prefer to reallocate more heavily into long-term Treasuries to compensate for the lost duration. The random demand coefficient model allows for this more flexible portfolio adjustment, enabling investors to allocate funds disproportionately toward assets with similar characteristics.

4.1 Assets

Bonds are indexed by $n = 1, ..., N$. Each bond has a par amount outstanding $S_t(n)$, yield to maturity $y_t(n)$, and a vector of characteristics $\boldsymbol{x}_t(n)$, which includes rating, duration, coupon rate, and bid-ask spread. We focus on yield instead of price because bonds with different coupons or maturities can mechanically have different prices while having the same expected returns. For callable bonds and other bonds without definitive cash flows, we calculate yield by simulation, where conditional prepayment behavior is inferred through historical data. We do not use the credit spread because that assumes an exogenous Treasury yield curve, which we aim to endogenize. Our counterfactual analyses will focus on the risk premium component of yield, namely the term spread and credit spread.

Instead of individual bonds, we work with portfolios of bonds. This is because we are primarily interested in aggregate bond yields (e.g. the yields on 5-year BBB-rated bonds), and others have shown that investor elasticities vary at different aggregation levels (Li and Lin, 2024; Chaudhary, Fu, and Li, 2022). In our baseline framework, bonds are grouped into 3 classes (Treasury, MBS, and corporate), 6 rating groups (AA or higher, A, BBB, BB, B, CCC or lower), 30 maturity groups (1 year or less, ..., 30 years or longer), 11 coupon groups (0%, 1%, ..., 10% or higher), and callability (yes vs. no). For MBS, instead of grouping by remaining maturity, we group by issuance year and original term (15, 20, or 30 years), which is the standard practice. We focus on this level of portfolio aggregation to strike a balance between having a large enough cross-section to identify demand coefficients and capturing investor elasticities at the aggregate level. Working with bond portfolios also greatly simplifies computation.[8]

We treat cash and cash equivalents (including deposits, money market instruments, Treasury bills, and Treasury bonds with less than one year to maturity) as the base bond ($n = 0$).

[8] At a given point in time, there are on average 300+ Treasury CUSIPs, 25,000+ corporate CUSIPs, and 500,000+ MBS CUSIPs outstanding.

Cash carries the one-year Treasury yield, which is directly controlled by the Fed, so there is no market clearing. Cash has a AAA rating, 0 years to maturity, 0% coupon, and 0% bid-ask spread.

Other bonds (e.g. foreign bonds) and other assets (e.g. equities) are outside our model. Instead, we will treat investors' allocation between U.S. bonds and other assets as a parameter and study the effect of changing this parameter on equilibrium bond yields—for example, how bond yields would change if investors rebalance between bonds and other assets. We make the deliberate decision not to treat these outside assets as cash, which is conventionally done, because they can have large returns due to monetary policy, and treating them as yield-less cash may severely bias the results.

4.2 Investors

Investors are indexed by $i = 1, ..., I$. We focus on four types of institutional bond investors for which we have detailed data on portfolio holdings: mutual funds (including offshore ones), insurance companies, banks, and the Federal Reserve. Banks report coarser holdings (by bond classes and maturity buckets) and we assume that their portfolio weights within each reporting category are proportional to the amount outstanding. Many investors hold a small set of bonds, which is problematic for estimation. To address this, we group individual investors, resulting in 79 mutual fund groups (by Morningstar Category and by active vs. passive), 20 insurance company groups (by life vs. P&C and by size decile) and 10 bank groups (by size decile). The residual investors are grouped together, and their holdings are calculated as the difference between the combined holdings of our four types of investors above and the total amount outstanding for each bond.

Following Koijen and Yogo (2019), investor i's time t portfolio weight in bond n is modeled

as:

$$w_{i,t}(n) = \frac{\exp\{\alpha_{i,t} y_t(n) + \boldsymbol{\beta}'_{i,t} \boldsymbol{x}_t(n) + \epsilon_{i,t}(n)\}}{\sum_m \exp\{\alpha_{i,t} y_t(m) + \boldsymbol{\beta}'_{i,t} \boldsymbol{x}_t(m) + \epsilon_{i,t}(m)\}} \tag{5}$$

Intuitively, the portfolio weight of a bond depends on its indirect utility, which is determined by its yield $y_t(n)$, characteristics $\boldsymbol{x}_t(n)$, and latent demand $\epsilon_{i,t}(n)$. Notice how bond n's portfolio weight $w(n)$ depends not only on its own yield $y(n)$ but also on the yields of all other bonds $\{y(m)\}$. Latent demand for cash $n = 0$ is normalized such that $\exp\{\alpha_{i,t} y_t(0) + \boldsymbol{\beta}'_{i,t} \boldsymbol{x}_t(0) + \epsilon_{i,t}(0)\} = 1$.

This original form of demand specification implies a restrictive form of portfolio substitution pattern. Specifically, we can derive the semi-elasticity of portfolio weight with respect to yield as:

$$\frac{\partial w(m)/w(m)}{\partial y(n)} = \begin{cases} \alpha(1 - w(n)) & m = n \\ -\alpha w(n) & m \neq n \end{cases} \tag{6}$$

The cross-elasticity on the second line shows that when the yield on bond n changes, all other bonds' portfolio weights change by the exact same proportion, as m does not enter the expression at all. In other words, the investor simply scales up or down the rest of her portfolio. However, in reality, we should expect that the investor primarily substitutes bond n with the bonds that have similar characteristics, and the portfolio weights of bonds with disparate characteristics should not be affected as much (Chaudhary et al., 2022).

To capture the flexible portfolio substitution pattern, we use insights from the industrial organization literature (Berry et al., 1995) and introduce random coefficients: $\boldsymbol{\beta}_{i,t} \sim N(\mu_{i,t}, \Sigma_{i,t})$. Portfolio weights in Equation 5 then become an integral over the distribution of $\boldsymbol{\beta}$:

$$w_{i,t}(n) = \int \frac{\exp\{\alpha_{i,t} y_t(n) + \boldsymbol{\beta}'_{i,t} \boldsymbol{x}_t(n) + \epsilon_{i,t}(n)\}}{\sum_m \exp\{\alpha_{i,t} y_t(m) + \boldsymbol{\beta}'_{i,t} \boldsymbol{x}_t(m) + \epsilon_{i,t}(m)\}} dP(\boldsymbol{\beta}_{i,t}) \tag{7}$$

This allows demand across bonds to be correlated based on characteristics, with the correlation controlled by Σ. The semi-elasticity of portfolio weight to yield can be derived

as:

$$\frac{\partial w(m)/w(m)}{\partial y(n)} = \begin{cases} \frac{\alpha}{w(n)} \int \tilde{w}(n)(1-\tilde{w}(n))dP(\boldsymbol{\beta}) & m = n \\ -\frac{\alpha}{w(m)} \int \tilde{w}(m)\tilde{w}(n)dP(\boldsymbol{\beta}) & m \neq n \end{cases} \tag{8}$$

where portfolio weight conditional on demand $\boldsymbol{\beta}$ is given by $\tilde{w}(n) = \frac{\exp\{\alpha x_t(n) + \boldsymbol{\beta}' \boldsymbol{x}(n) + \epsilon(n)\}}{\sum_m \exp\{\alpha y_t(m) + \boldsymbol{\beta}' \boldsymbol{x}_t(m) + \epsilon(m)\}}$. We can see that the cross-elasticity between two bonds now depends on the *covariance* of the portfolio weights of the two bonds, where the probability space is over $\boldsymbol{\beta}$. As a result, if two bonds have similar characteristics, their portfolio weights will have higher covariance, and their cross-substitution will be stronger. This portfolio flexibility is essential for us to capture portfolio substitution channels such as mortgage convexity (Hanson, 2014).

4.3 Identification

Latent demand ϵ is likely correlated with yield, so we need instruments for identification. We construct two sets of instruments. The first set of instruments consists of bond characteristics, based on the standard assumption that the supply of bonds and their characteristics are exogenous to investors. We include both the bond's own characteristics and those of its peers, where a peer is defined as bonds whose rating, duration, coupon are within one standard deviation of the target bond's.

Our second set of instruments is flow-induced trading by other investors Lou (2012); Gabaix and Koijen (2021). The idea is that inflows into (and outflows from) an investor create disproportionate buying (or selling) pressure on the bonds that the investor already owns ex ante, e.g., due to investment mandates. Flows to other investors, after being residualized against common factors, are therefore plausibly exogenous shocks to yields for the investor of interest. Formally, mutual fund i's idiosyncratic flows at time t are given by residuals

from a principal component regression:

$$InvestorFlow_{i,t} = a + \sum_k b_k PC_{k,t} + \tilde{InvestorFlow}_{i,t}$$

where $PC_{k,t}$ denotes the k'th principal component of flows across mutual funds. These investor-level idiosyncratic flows are then aggregated for each bond, excluding flows to the investor of interest:

$$FIT_{-i,t}(n) = \sum_i \frac{AmountHeld_{i,t-1}(n)}{AmountOutstanding_{t-1}(n)} \tilde{InvestorFlow}_{i,t} \tag{9}$$

To verify the relevance of flow-induced trading as an instrument for bond yields, we follow Koijen and Yogo (2019); Bretscher et al. (2021) and run the following OLS regression for each investor at each time:

$$y_{i,t}(n) = \tilde{\beta} FIT_{-i,t}(n) + \tilde{\gamma} Controls + \tilde{\epsilon}_{i,t}(n).$$

Table A1 shows the average t-statistics of $\tilde{\beta}$ for different investor periods and time segments. The t-statistics are, on average, significantly higher than the 5% critical value in Stock and Yogo (2005). Similar to the characteristics, we include both the bond's own flow-induced trading and its peers' flow-induced trading, with peers being similarly defined as above. These instruments, which include characteristics and flow-induced trading on the bond and its peers, are denoted by $\boldsymbol{z}(n)$.

4.4 Estimation

We want to estimate demand for yield $\alpha_{i,t}$ and characteristics $(\boldsymbol{\mu}_{i,t}, \Sigma_{i,t})$ for each investor at each time. We make a number of assumptions to simplify computation. We restrict Σ to be

a diagonal matrix. That is, we assume that there is no correlation in demand for different characteristics within each portfolio formation. To simplify computation further, we only allow random coefficients on rating and duration. Because identification primarily comes from changes in demand over time Nevo (2000), we include not only the investor's current holdings but also their holdings in the quarter before and the quarter after.

We follow the estimation procedure in Berry et al. (1995). Specifically, we define the mean utility of a bond as $\delta := \alpha y + \boldsymbol{\mu}'\boldsymbol{x} + \epsilon$ and rewrite Equation 7 as:

$$w_{i,t}(n) = \int \frac{\exp\{\delta_{i,t}(n) + \boldsymbol{\eta}'_{i,t}\boldsymbol{x}_t(n)\}}{\sum_m \exp\{\delta_{i,t}(m) + \boldsymbol{\eta}'_{i,t}\boldsymbol{x}_t(m)\}} dP(\boldsymbol{\eta}_{i,t})$$

where $\boldsymbol{\eta} = \boldsymbol{\beta} - \boldsymbol{\mu}$. In other words, $\boldsymbol{\eta}$ is the random part of $\boldsymbol{\beta}$. We can invert the equation above to express mean utility as a function of portfolio weights. This inversion does not have an analytical solution but can be solved via contraction mapping:

$$\delta^{h+1} = \delta^h + \log(w) - \log(w(\delta^h))$$

where w is the observed portfolio weight and $w(\delta^h)$ is the portfolio weight under the current guess of mean utility δ^h. After obtaining mean utility δ, we can then perform a linear IV GMM regression of the form:

$$\delta(n) = \alpha y(n) + \boldsymbol{\mu}'\boldsymbol{x}(n) + \epsilon(n)$$

Denote $\theta = (\alpha, \boldsymbol{\mu}, \Sigma)$. Moments are then constructed by interacting the estimated latent demand $\epsilon(n)$ with the instruments $\boldsymbol{z}(n)$ to form:

$$g(\theta) = \frac{1}{N} \sum \boldsymbol{z}(n)'\epsilon(n)$$

The GMM problem is:

$$\min_{\theta} g(\theta)' W g(\theta)$$

where W is the weighting matrix.

Table A2 and Figure A4 show our estimated demand coefficients. The mean coefficients $\boldsymbol{\mu}$ can be roughly interpreted as semi-elasticities. For example, if a bond's duration increases by 1 year, its portfolio weight in a long-term bond fund's portfolio is expected to increase by 10-30%. However, we note that the precise semi-elasticities vary from bond to bond depending on its substitutability, as can be seen from the integral in Equation 8.

These mean coefficients $\boldsymbol{\mu}$ exhibit expected regularities. High-yield funds have higher coefficients on credit rating (i.e. more credit risk) than investment-grade funds. Long-term funds have higher coefficients on duration than short-term funds. Insurance companies have low credit rating coefficients, similar to investment-grade funds, reflecting the fact that they are subject to rating-based capital regulation. Life insurance companies have high duration coefficients and high coupon coefficients, reflecting the characteristics of life insurance and annuity liabilities. Banks have low coefficients on the bid-ask spread, especially after the 2008 financial crisis, reflecting the increased stringency of bank liquidity regulations.

There is noticeable variation in mean coefficients $\boldsymbol{\mu}$ over time. For example, demand for duration by life insurers is quite volatile, increasing steadily during monetary easing after the 2008 financial crisis, decreasing following QE tapering in 2013, and rising again during monetary easing after the 2020 COVID crisis. This dependency of duration demand on interest rates is consistent with the "reaching-for-duration" behavior documented Ozdagli and Wang (2019).

Our estimation shows that within-portfolio demand variation Σ is economically meaningful. For almost all investors and for both rating and duration, σ is well above zero and similar in magnitude to the mean coefficient. This means that, for example, life insurance companies

not only prefer long-duration bonds *on average*, but also exhibit varying preferences *within each portfolio construction*. They sometimes tilt towards bonds with short duration (e.g., to match short-duration products sold, such as group term life insurance) and sometimes tilt towards bonds with long duration (e.g., to match long-term annuities and other products sold with distant payoffs).

Yield coefficients α are small and sometimes negative. This is due to the valuation effect. Consider an investor who is completely inelastic to yield; when a bond's yield increases, its price decreases, and its portfolio weight declines, resulting in the yield coefficient appearing as negative. This value effect is particularly pronounced for long-duration bonds, so α is mechanically lower for long-term investors than for short-term investors.

To better understand the economic magnitude of yield coefficients α, we calculate price elasticities. We express price elasticities as a simple transformation of yield semi-elasticities from Equation 8:

$$\frac{\partial q(m)/q(m)}{\partial p(n)/p(n)} = \begin{cases} -1 - \frac{100\alpha}{w(n)d(n)} \int \tilde{w}(n)(1-\tilde{w}(n))dP(\boldsymbol{\beta}) & m = n \\ \frac{100\alpha}{w(m)d(n)} \int \tilde{w}(m)\tilde{w}(n)dP(\boldsymbol{\beta}) & m \neq n \end{cases} \tag{10}$$

where portfolio weight $w(m)$ and amount of par value held $q(m)$ are connected through:

$$w(m) = p(m)q(m)/A$$

and bond n's duration $d(n)$ approximates the relationship between yield and price:

$$\frac{d(n)}{100} = -\frac{\partial p(n)/p(n)}{\partial y(n)}$$

The equation shows that price elasticity varies for each pair of bonds. Indeed, a key feature of our framework is that cross-elasticities can vary depending on the bonds' similarity in

characteristics. Bonds with similar characteristics exhibit higher covariance in conditional portfolio weight $\tilde{w}$, which leads to increased cross-substitution. Instead of presenting cross-elasticities for all millions of pairs of bonds, we group bonds by rating letters (AAA, AA, ..., CCC) and duration buckets (1-3Y, 3-5Y, ..., 15-30Y) and calculate the averages.

Table 2 shows estimated own-price (cross-price) elasticities, averaged across bonds (bond prices) with the given rating letters or duration buckets and averaged across mutual funds, insurance companies, or banks over time. The diagonal numbers show own-price elasticities according to Equation 10, with $m = n$. Own-price elasticities are almost always negative and generally less than 5 in magnitude. Mutual funds and banks have the largest own-price elasticities, whereas insurers have the smallest price elasticities. The average own-price elasticity across funds, insurers, and banks, weighted by their AUM, is -2.17. The average elasticity without funds is -1.22, meaning that a 1% mutual fund flow-induced demand shock implies -0.82% return, or +8.2 bps in 10-year bond yield. Our estimated price elasticity is very similar to that of Chaudhary et al. (2022), who finds that the market multiplier (the average price elasticity) is 1.25 (0.8) at the level of coarse rating $\times$ short/medium/long-term maturity portfolios and 0.33 (3) at the level of detailed rating *times* quarters to maturity portfolios. Thus, our portfolios at the coarse rating $\times$ years to maturity $\times$ rounded coupon rate level is in the middle, and our estimated price elasticity is also in the middle.

The off-diagonal numbers show cross-price elasticities according to Equation 10, with $m \neq n$. More specifically, the cell in row m and column n shows the percent change in the holding of a bond in row m due to a one-percent change in the price of a bond in column m, averaged across all bond pairs with the given combinations of rating letters or duration buckets. As a key feature of our innovation to incorporate random coefficients, cross-elasticities vary across bond pairs. Notably, the largest cross-elasticities occur close to the diagonal. This means that cross-elasticities are largest among bonds that are most similar in rating or duration. This localized substitution pattern has been demonstrated to be a key feature of the bond

market (Chaudhary et al., 2022) and we are able to achieve this through the incorporation of random coefficients.

To illustrate the difference with the original fixed coefficient framework, we calculate the same elasticity tables when demand coefficients β are fixed at their means μ. In other words, coefficient variation σ is set to zero. Table A3 shows that, consistent with the prediction in Equation 6, fixed coefficients produce rigid homogeneous cross-substitution, as the cross-elasticity numbers are essentially invariant for each column.[9]

4.5 Equilibrium

In equilibrium, market clears, meaning that the demand by investors equals the market supply for each bond. Given the bond outstanding (S), bond characteristics ($\boldsymbol{x}$), investor AUM in bonds (A), investor demand coefficients ($\theta = (\alpha, \boldsymbol{\mu}, \Sigma)$), investor latent demand (ϵ), and equilibrium bond yields (y), the market clearing condition is:

$$S_t(n)P_t(n) = \sum_{i=1}^{I} A_{i,t} w_{i,t}(n) \tag{11}$$

where the left-hand side represents the market value of bonds outstanding, and the right-hand side represents total demand across all investors. The price of a bond is the sum of its periodic coupon payments and its final principal payment, discounted by yield: $P = \sum_{\tau=1}^{T} Ce^{-y\tau} + e^{-yT}$. Market clearing applies to all bonds except for cash ($n = 0$), where the supply is controlled by the Fed.

Similar to Koijen, Richmond, and Yogo (2023), we endogenize investor AUM with respect

[9] Cross-elasticity is not exactly the same within each column because of variation in group composition and duration adjustment (Equation 10).

to asset prices. Bond AUM obeys the following law of motion:

$$A_{i,t} = A_{i,t-1}R_{i,t} + T_{i,t} \tag{12}$$

where T denotes net purchases of bonds, measured by changes in par values Q and prices P:

$$T_{i,t} = \sum_n (Q_{i,t}(n) - Q_{i,t-1}(n))P_{t-1}(n)$$

and R denotes the return on the bond portfolio, given by:

$$R_{i,t} = \sum_n w_{i,t}(n)R_t(n)$$

where bond return includes both price changes and coupon payments. Note that we use portfolio weights as of the current equilibrium because we want to endogenize the effects of current portfolio weights on prices. We separate out net purchases that are driven by flows $T^F_{i,t} = A_{i,t-1}F^{\%}_{i,t}$ and other net purchases $T^O_{i,t} := T_{i,t} - T^F_{i,t}$. $F^{\%}_{i,t}$ denotes flows as the fraction of the investor's total AUM that includes both bonds and non-bonds $F^{\%}_{i,t} = F^{\$}_{i,t}/A^{total}_{i,t-1}$.

Notice that yields enter the market clearing condition through R, A, and w. If we treat bond yields y as the only endogenous variable, we can solve for equilibrium bond yields as an implicit function:

$$y(S, \boldsymbol{x}, A, \boldsymbol{\theta}, \epsilon). \tag{13}$$

We use the following procedures to derive counterfactual bond yields numerically. First, we take an initial guess at yields $\{y(n)\}$ (e.g., the actual yields from the last period). Then, given bond characteristics $\{\boldsymbol{x}(n)\}$, investor demand $\{\boldsymbol{\theta}(n)\}$, and latent demand $\{\epsilon(n)\}$, we obtain portfolio weights $\{w(n)\}$. Given bond AUM $\{A\}$ and portfolio weights $\{w(n)\}$, investors' total dollar demand for bond n is $\sum A_{i,t}w_{i,t}(n)$, the right-hand side of Equation 11. If total investor demand is higher (lower) than market value of bond supply, the yield needs to be

adjusted downward (upward) to close the gap. We follow the method in Koijen and Yogo (2019) to control the speed of adjustment.

4.6 Decomposition

Using the method above to calculate counterfactual bond yields, we can perform an empirical decomposition of bond yield changes into different channels (Koijen and Yogo, 2019). For each channel c, we derive the market-clearing bond yields before and after its change while holding all other channels fixed:

$$\Delta y_t(c) := y(c_t, -c_{t-1}) - y(c_{t-1}, -c_{t-1}) \tag{14}$$

where c refers to the channel of interest and $-c$ refers to the collection of all other channels. For example, to quantify changes in yields from $t-1$ to t that are due to changes in amount outstanding S, we separately feed the model S_{t-1} and S_t while holding all other channels fixed at their values as of $t-1$, and we calculate the market-clearing bond yields $y(S_{t-1}, x_{t-1}, A_{t-1}, \theta_{t-1}, \epsilon_{t-1})$ and $y(S_t, x_{t-1}, A_{t-1}, \theta_{t-1}, \epsilon_{t-1})$ from Equation 13. We do this for supply-side channels, including amount outstanding S, bond characteristics $\boldsymbol{x}$, and the demand-side channels, including investor AUM A, demand for characteristics $\theta = (\alpha, \mu, \Sigma)$, and latent demand ϵ.

Changes in bond AUM can come from bond returns — which we have endogenized in Equation 12 — or from purchases or sales of bonds. As described in the previous section, we further separate out flow-induced net purchases T^F and other net purchases T^O. Intuitively, T^F shows changes in bond AUM if the investor proportionally scales up or down its bond portfolio in response to flows. Any remaining changes in bond AUM T^O represent the allocation between bonds and other non-bond assets (e.g., equities).

We can further refine the decomposition to capture heterogeneity across investors and across bonds. For example, we calculate yield changes separately for mutual fund flows, insurance company flows, and bank flows. As another example, rather than lumping together yield changes due to all demand changes, we partition yield changes into changes in demand coefficients on 1) credit rating, 2) duration, 3) coupon rate, and 4) bid-ask spread.

Changes in credit ratings are reflected in the restructuring of bond portfolios based on updated ratings while keeping all other bond characteristics unchanged. For example, suppose there is a widespread credit migration from AA to BB; in this case, the amount outstanding of the AA portfolios would shrink, while that of the BB portfolios would expand. Bonds that are redeemed during the process are assumed to have unchanged ratings and bid-ask spreads.

Bonds mature over time, so duration naturally shortens, and the amount outstanding naturally disappears at maturity. We focus on "active" changes in duration, defined as duration changes for callable bonds (e.g. MBS) due to changes in conditional prepayment rates. We pool together the natural maturing process with changes in the amount outstanding (e.g., new issuance and early redemption). To see why, suppose that there is a representative firm that borrows equally across the maturity spectrum, from 1 year to 30 years. This means that every year an equal amount of bonds will mature, an equal amount of new 30-year bonds will be issued, and duration shortens by 1 for all other bonds. In this case, it is clear that the amount outstanding is constant, and we should not separate natural redemption from new issuance.

5 Dissecting Monetary Transmission to Bond Yields

With our demand system framework laid out in the previous section, we set out to measure how much each channel (e.g. changes in investor demand for duration) contributes to the sensitivity of bond yields to the short-term rates (i.e. one-year Treasury rates). The contribution of channel c to yield sensitivity to monetary policy is measured through the following regression:

$$\Delta y_t(c) = \alpha + \beta \Delta r_t + \gamma X_t + \epsilon_t \tag{15}$$

where $\Delta y_t(c)$ denotes year-over-year yield changes attributable to channel c according to Equation 14, Δr_t year-over-year changes in the one-year Treasury rate, and X_t macroeconomic variables including contemporaneous GDP growth, inflation rate, unemployment rate changes, and changes in VIX. We focus on year-over-year changes (e.g., from 2010Q2 to 2011Q2) because some channels, such as fund flows, operate at relatively low frequency. Standard errors are adjusted for serial correlation with four lags (Newey and West, 1994).

We focus on the risk premium component of bond yields, namely term spreads and credit spreads. To measure term spread changes, we follow Nagel and Xu (2024) and use survey forecasts from the Survey of Professional Forecasters (SPF). Specifically, changes in T-year Treasury yields that arise from changes in current and expected short rates are given by:

$$\Delta SR = \frac{1}{T} \sum_{k=0}^{T-1} (E_+ i_k - E_- i_k)$$

where i_k denotes the k-year forward rate. Since forecasts are only available for up to five quarters ahead, we assume that forecasters model the short rate process as AR(1) and calculate changes in longer-term forecasts ($k > 1$) as:

$$E_+ i_k - E_- i_k = \gamma^{k-1} (E_+ i_1 - E_- i_1).$$

Term spread changes are then calculated as the remaining part of Treasury yield changes:

$$\Delta TS = \Delta y - \Delta SR.$$

Credit spread is measured for corporate bonds as the excess yield over duration-matched Treasury bonds.

5.1 Term spread

Figure 7 shows results for the monetary sensitivity of the 10-year term spread. In Panel A, the black bar on the right shows the observed term spread sensitivity to monetary policy. Consistent with existing literature, monetary policy has a substantial impact on term premia. A 100 bps increase in the one-year Treasury yield is associated with a 20 bps increase in the 10-year term spread.

The remaining red and blue bars in Panel A display our estimated contributions from different channels, where red (blue) indicates positive (negative) contributions. Note that the channels do not necessarily sum to the total monetary sensitivity because latent demand ϵ drives some variation in bond yields, similar to the findings in Koijen and Yogo (2019).

Investor flows are a leading factor in enhancing the monetary sensitivity of bond yields, increasing the 10-year term spread sensitivity to monetary policy by 27 bps. Panel B further decomposes the effect into different investor groups and shows that the contribution primarily comes from bond mutual funds and ETFs (16 bps) and banks (6 bps). During monetary easing (tightening), bond mutual funds and banks experience large inflows (outflows) of retail capital, which creates significant buying (selling) pressure on bonds (Drechsler et al., 2017; Fang, 2023; Darmouni et al., 2024). At the same time, other investors do not offset flow-induced demand from bond funds and banks, due to investment mandates and other

forms of yield inelasticity.[10]

Allocation between bonds and other assets (e.g., equities) slightly dampens the monetary sensitivity of the 10-year term spread by 5 bps. Panel C shows that this is primarily due to balanced funds, i.e., funds with flexible mandates to invest in a broad set of assets. During monetary easing (tightening), long-duration bonds experience large valuation increases (decreases), which prompts investors such as balanced funds and pension funds with fixed investment ratios to sell (buy) bonds and rebalance into (away from) other assets (Lu and Wu, 2023).

Demand for characteristics amplifies the monetary sensitivity of the 10-year term spread by 16 bps. Panel D shows that the effect mainly comes from demand for duration (8 bps). During monetary easing (tightening), the duration of insurance and pension liabilities increases (decreases), which requires these investors to increase (decrease) their asset duration in order to stay hedged against future interest rate shocks (Domanski et al., 2017; Ozdagli and Wang, 2019). There is also a meaningful effect from demand for coupon rate (4 bps). Daniel, Garlappi, and Xiao (2021) shows that monetary easing increases investor demand for high-income assets such as high-coupon bonds in order to maintain income yield.

Supply of characteristics amplifies the monetary sensitivity of the 10-year term spread by 10 bps. Panel E shows that the supply of bond duration alone amplifies monetary sensitivity by 9 bps. As detailed in Section 4.6, natural maturity shortening is excluded here, so all changes in duration come from callable bonds such as MBS. Hanson (2014) shows that, during monetary easing (tightening), the duration of callable bonds decreases (increases), which leads investors to tilt the rest of their portfolios towards (away from) long-term bonds in order to maintain duration neutrality. Note that the random-coefficient framework allows

[10]We can derive similar estimates through a back of envelop calculation. Fang (2023) shows that 100 bps increase in the short-term rate is associated with 10% bond fund outflow, which translates to about -2% market wide demand. Given the average price elasticity of about 1.5 for non-bond investors (Section 4.4), this implies a return of -1.33%, which translates to an yield increase of 25 bps for the average bond duration of 5.6.

for localized substitution with respect to characteristics, which is crucial for capturing this channel.

Changes in the outstanding amount of bonds are a key force in dampening the bond term spread's sensitivity to monetary policy. During monetary easing (tightening), governments, households (mortgage borrowers), and corporations issue more (less) new bonds, increasing (decreasing) the total amount of bonds outstanding, which raises (lowers) equilibrium bond yields. Our estimates show that issuance and redemption together dampen the monetary sensitivity by 32 bps. Panel F shows that the effect is across the board for all bond classes, with the supply of municipal bonds having the smallest effect, possibly due to its small size in relative terms.

To further understand this issuance sensitivity to monetary policy, we estimate the price elasticity of net issuance through the following OLS regression, run separately for each class of bonds:

$$\Delta \log S_t(n) = \tilde{\alpha} \Delta \widehat{\log} P_t(n) + \tilde{\beta}' x_t(n) + \tilde{\epsilon}_t(n)$$

where, for each bond portfolio n, $\Delta log S_t(n)$ denotes the log change in the amount outstanding, $\Delta \widehat{\log} P_t(n)$ denotes the log change in price instrumented with contemporaneous flow-induced trading (Equation 9), and $x_t(n)$ represents bond characteristics such as credit rating and duration. Table A4 shows the results and confirms that bond issuance is highly sensitive to bond prices, particularly for Treasury and corporate bonds. The magnitude is smaller but still on the same order as investor elasticity in Table 2. These findings are consistent with the evidence that governments, households, and corporations are sensitive to credit market conditions (e.g. Greenwood, Hanson, and Stein, 2010; Ma, 2019).

Our results also highlight the importance of considering issuance and redemption by the real sector, rather than focusing solely on bond yields, when evaluating monetary policy transmission. In particular, our findings provide an explanation for the small magnitude of

yield sensitivity to monetary policy at low frequency (Hanson et al., 2021) — the lack of yield sensitivity partially reflects the strength of issuance sensitivity, rather than necessarily indicating a failure of transmission. Moreover, the results reveal a potential substitutability between public issuance by governments and private issuance by corporations and households. For example, during monetary easing, corporate issuance and mortgage borrowings would likely have been greater without government issuance. In other words, public issuance can crowd out private issuance.

Panel A of Figure A5 shows the sensitivity of the term spread to monetary policy across the term structure. Consistent with existing literature (e.g. Hanson and Stein, 2015), the black line indicates that monetary policy has a large effect on term spreads many years into the future. The effect is hump-shaped, with a slightly higher impact in the 5-10 year range, but remains above zero for durations beyond 15 years.

The colored bars show contributions from the top channels and suggest that the importance of a channel is heterogeneous across durations. Investor flows are more important for short-duration term spreads than for long-duration term spreads, reflecting the fact that mutual funds and banks invest more in short-duration bonds compared to other bond investors, such as insurance companies.

Demand for duration is more important for long-duration term spreads and can even have a negative contribution to short-duration term spreads. This is likely because when insurers and pension funds reach for duration, they simultaneously sell short-term bonds and buy long-term bonds, which twists the term structure instead of lifting it upwards everywhere.

Supply of duration mainly amplifies monetary sensitivity in the 5-10 year range. This is because callable bonds, such as MBS, have a median duration of 7.53 (Table 1), so changes in their duration mainly affect bonds in the nearby duration. During monetary easing (tightening), the duration of callable bonds decreases (increases), which leads to portfolio

substitution towards (away from) other bonds with a 5-10 year duration, pushing down (up) their yields.

The effect of the amount outstanding is concentrated in the 5-15 year range, which coincides with the most common duration of new issuance of corporate bonds. The effect of the amount outstanding is lowest in the shortest-duration range. This is partially because, during monetary easing, firms and households issue new long-term bonds to preemptively refinance bonds that are about to mature, which lowers the amount outstanding of short-duration bonds and lowers their yields.

5.2 Credit spread

Figure 8 shows contributions from different channels for the 10-year BBB spread, which is the difference between the 10-year BBB-rated corporate bond yield and the 10-year Treasury yield. In Panel A, the black bar on the right represents the total observed monetary sensitivity, indicating that the BBB spread narrows by 4 basis points for every 100 basis points increase in the one-year Treasury rate.

The red (blue) bars indicate positive (negative) contributions from different channels. One salient result is that, without changes in the amount of bonds outstanding, the sensitivity of credit spreads to monetary policy would have been significantly higher, as shown by the large blue bar on the amount outstanding. Panel F shows that this is primarily due to opposing effects from corporate bond supply and the supply of Treasury bonds and MBS. During monetary easing (tightening), firms issue more (less) bonds, which increases (decreases) credit spreads and, therefore, decreases the total sensitivity of credit spreads. At the same time, governments and government-sponsored mortgage borrowers, which have minimal credit risk, also borrow more (less), which increases the gap between risk-free yields and corporate yields.

Demand for characteristics increases credit spread sensitivity to monetary policy by 5 bps. Panel D shows that the demand for ratings has heterogeneous effects across investors. During monetary easing, life insurers tend to decrease credit risk-taking due to tighter regulatory constraints (Li, 2024). In contrast, investors such as mutual funds tend to tilt towards bonds with higher credit risk in order to obtain higher yields (Choi and Kronlund, 2018). As a result, insurers' demand for ratings decreases monetary sensitivity, whereas mutual funds have the opposite effect. Reaching for income can lead to lower credit spreads since lower-rated corporations are a main source of high-coupon bonds (Daniel et al., 2021).

Panel B of Figure A5 shows monetary sensitivity across the credit spectrum, from AA (or higher) to CCC (or lower). Here we focus on bonds with a 5-year duration, as there are few speculative-grade bonds with longer durations.[11] The observed monetary sensitivity, represented by the black line, is mostly negative and downward sloping with respect to credit risk. This is consistent with the negative correlation between credit spreads and risk-free rates (e.g. Duffee, 1998).

The colored bars indicate that the impact of a channel can exhibit significant heterogeneity across the credit spectrum. The effect of investor flows concentrates on A-rated and BBB-rated bonds. This reflects the fact that during monetary easing (tightening), there are substantial inflows to (outflows from) investment-grade bond funds, but not as much to high-yield bond funds (Fang, 2023).

Insurer demand for credit ratings increases the sensitivity of A-rated bonds to monetary policy and decreases the sensitivity of other lower-rated bonds. This is consistent with the fact that, during monetary easing, insurers become more constrained by regulatory capital and tilt towards higher-rated bonds with lower regulatory charges. A-rated bonds offer the highest yields while having the lowest regulatory charges (Becker and Ivashina, 2015). The demand for credit ratings from other investors has the opposite effect, increasing (decreasing)

[11] A typical speculative-grade bond is issued with 10 years to maturity and 7.8 of duration.

their risk-taking during monetary easing (tightening) and amplifying the sensitivity of bonds rated BBB or lower to monetary policy.

Changes in the amount outstanding have a large negative effect on the credit spread sensitivity to monetary policy across the credit spectrum. The effect is largest for BB-rated firms, reflecting the combined forces of: 1) the issuance and redemption of these firms being highly sensitive to monetary policy; 2) the weak substitution between BB-rated bonds and other bonds, which means quantity shocks can have particularly large price effects.

5.3 Evolution over time

Our analyses so far focus on the average effect—for example, what is the average contribution of investor flows to bond yield sensitivity to monetary policy over the entire sample period. It is natural to expect that the strength of these transmission channels can vary over time, contingent on different levels of the underlying state variables. To analyze *changes* in different transmission channels over time, we split the sample in half: one from the beginning of 2003 to the end of 2012, and the other from the beginning of 2013 to the end of 2022. We perform our decomposition exercise separately for these two periods.

Figure 9 shows the results. The amplification effects of investor flows have increased significantly in the latter half of our sample, from 0.16 to 0.25 percentage points. This reflects the secular rise of bond mutual funds relative to insurance companies and banks (Ma et al., 2025), as well as the increased flightiness of bank deposits in the low-rate environment. Consequently, changes in the short-term rates are associated with larger quantities of flow-induced bond demand relative to bonds outstanding [12] The amplification effect of changes in duration has declined, reflecting the fact that insurance companies' convexity exposure

[12] One reason for the growth of mutual funds is the secular shift from defined-benefit to defined-contribution pension plans, where retirees directly select mutual funds in their 401k accounts, instead of delegating to a pension manager.

has reduced over time (Ozdagli and Wang, 2019).

The dampening effect of the amount outstanding (due to issuance and redemption) has almost doubled, from -0.21 to -0.39 percentage points. Bond issuance, particularly those by corporations and mortgage borrowers, has become more sensitive to market conditions, which counteracts the amplification effects from investors. As a result, the net effect of investor demand and net issuance has declined over time, from 0.20 in the first half of our sample to 0.03 in the second half of our sample. Our results provide an explanation for the puzzling findings in Hanson et al. (2021) regarding the decline of bond yield sensitivity to monetary policy at an annual frequency. Rather than a sign of weakened monetary transmission, we show that the decline in yield sensitivity is partly attributable to the increase in issuance sensitivity, a sign of strengthened transmission to the real sector.

These time series dynamics suggest that the strength of a monetary transmission channel depends on the relevant state variables. To further understand this state dependency, we ask what changes would occur in bond yields in response to a unit increase in the short-term interest rate when some state variables are set at different percentiles of their distributions. Counterfactual bond yields are derived in the same manner as before (Section 4.6), and all other parameters are held fixed. For example, we will quantify the contribution of bond fund flows for different degrees of bond fund flow sensitivity to monetary policy, while investors' AUM, their demand for characteristics, and the characteristics and amount of bonds outstanding are held fixed at their values as of year-end 2022.

The results are shown in Table 3. We focus on the 10-year term spread and the four channels that ranked the highest in our previous decomposition exercise, further narrowed down to a specific dimension: bond fund flows, insurer demand for duration, the level of MBS duration, and the amount of corporate bonds outstanding. Starting with Panel A, the middle cell shows the average contribution of bond fund flows to the 10-year term spread in response to a 100 bps increase in the policy rate, when all bond funds experience an 8% outflow (which is

the average monetary sensitivity across funds over time) and each investor's elasticity is set to its median level over time. The contribution (20 bps) is higher than that from our decomposition exercise (16 bps), reflecting the fact that bond funds account for a larger share of the bond market in 2022 than in earlier periods. The other cells show bond fund flow contributions when the two state variables are set to different values. The northeast cell shows that when bond fund flows are twice as sensitive to monetary policy as the observed average, and when the elasticity of other investors is at the lowest decile of the distribution, the contribution from bond fund flows rises to almost four times as large. On the other hand, when bond fund flows are half as sensitive to monetary policy and other investors are much more elastic to any price impacts created by bond fund flows, the amplification effect of bond fund flows is significantly weakened.

Panel B focuses on changes in insurer demand for duration. On average, when the short-term rate increases by 100 bps, the mean coefficient (μ) of insurer demand for duration falls by 0.12, as shown by the middle cell. The associated decline in demand for long-term bonds leads to an 8 bps increase in the 10-year term spread when other investors' yield coefficients are at historical means. This effect is greatly amplified (dampened), when the sensitivity of insurer demand for duration increases (decreases) or when investor elasticity decreases (increases), as shown by the northeast (southwest) corner of the table.

Panel C focuses on the level of MBS duration. When the short-term rate increases, the duration of MBS increases by 20 bps on average, as refinancing activities are expected to fall. This relationship, known as mortgage convexity, depends on the past path of mortgage rates (Eichenbaum, Rebelo, and Wong, 2022). If past mortgage rates were high and most outstanding mortgages carry high coupon rates, then additional increases in mortgage rates would not significantly discourage refinancing activities. Indeed, the sensitivity of MBS duration to the one-year Treasury rate can be as high as 0.49 during the recent 2022-23 rate hike and nearly zero during the 2003-07 rate hike, when many outstanding mortgages still

carried high coupons from the previous rate cycles. The estimates show the amplification effect of the MBS duration channel depends critically on MBS convexity, as well as investor elasticity, i.e. how much yield effects are required to offset the supply gap created by MBS duration changes.

Lastly, Panel D shows the distribution of effects from changes in corporate bond outstanding due to issuance and redemption. On average, 100 bps increase in the short-term rate is associated with 4% reduction in corporate bond outstanding. This sensitivity has increased over time, reflected in Figure 9. On average, corporate bond issuance and redemption dampen bond yield sensitivity to monetary policy by 18 bps, as shown in the middle cell. This effect is significantly magnified (reduced) when bond issuers are more (less) sensitive to rate changes and when investors are less (more) elastic, as more (less) yield changes are required for investors to adjust the quantity of their demand.

Investor composition has been shown to be an important state variable for the bond market (Coppola, 2022; Li and Yu, 2022; Fang, 2023). There has been a secular rise in bond mutual funds and ETFs relative to other bond investors, and this trend is poised to continue. Our next exercise asks: what would be the bond yield sensitivity to monetary policy if bond funds become larger or smaller relative to other investors? To make the analysis tractable, we examine the counterfactual outcomes of reallocating bond AUM between bond funds and life insurers, keeping their total bond AUM constant at its value as of year-end 2022. All other state variables, such as other investors' AUM and their demand coefficients, are also set to their year-end 2022 values. The responses of state variables to monetary policy, such as bond fund flow sensitivity to monetary policy, are set to their means estimated using the entire sample period.

The results are shown in Table 4. Panel A focuses on term spread sensitivity to monetary policy. In the middle column, we reallocate bond fund AUM and life insurer AUM such that they are in a 1:1 ratio, which is very close to reality at year-end 2022. In response to a 100

bps policy rate hike, our framework predicts an 18 bps increase in the 10-year term spread, combined across all the channels. If more bond AUM is reallocated to bond funds so that the ratio between bond fund AUM and life insurer AUM is 2 (shown in the rightmost column), then term spread sensitivity to monetary policy will be significantly amplified; conversely, if bond AUM is reallocated away from bond funds, the sensitivity will decrease.

More importantly, the shift in investor composition has heterogeneous effects across the term structure, as shown by the vertical direction. The reallocation of AUM towards bond funds— which corresponds to moving from left to right— amplifies term spread sensitivity for short-term bonds (the top rows) but dampens it for long-term bonds (the bottom rows). This is because bond funds and life insurers tilt towards different ends of the term structure. Therefore, a shift in AUM towards bond funds will amplify the yield sensitivity of short-term bonds more, through the bond fund flow channel, whereas a shift in AUM towards life insurers will primarily amplify the yield sensitivity of long-term bonds, through the insurer duration hedging channel.

Panel B of Table 4 focuses on 5-year BBB spread sensitivity. Similarly, changes in the relative AUM of bond funds and life insurers will change the relative weights of the underlying transmission channels. In response to monetary tightening, bond funds tend to decrease credit risk-taking and reduce the portfolio weights of low-rating bonds relative to high-rating bonds (Choi and Kronlund, 2018). Life insurers tend to do the opposite due to the relaxation of capital constraints (Li, 2024). Therefore, an increase in the AUM of bond funds relative to life insurers (from left columns to right columns) will raise credit spreads during monetary tightening, especially for bonds with lower credit ratings (the bottom rows).

In summary, this section demonstrates that the contribution of a channel can vary significantly over time, depending on the relevant state variables. Investor elasticity is a particularly important state variable across all channels, as it determines the magnitude of price impacts required to absorb imbalances between demand and supply. We illustrate how our

demand system framework can be used to analyze why a specific monetary policy episode has experienced weak or strong transmission. Additionally, it can be easily parametrized to make predictions for future monetary policy actions.

5.4 Unconventional monetary policies

In this sub-section, we use our framework to dissect the transmission of quantitative easing (QE). There have been four QE episodes:

- QE1: from November 2008 to June 2010, $300 billion Treasury bonds, $1,250 billion agency MBS, and $175 billion agency direct obligations
- QE2: from November 2010 to June 2011, $600 billion Treasury bonds
- QE3: from September 2012 to October 2014, $790 billion Treasury bonds and $823 billion agency MBS
- QE4: from March 2020 to March 2022, $3,000 Treasury bonds and $1,200 agency MBS

In order to make the different episodes comparable to each other, we rescale everything to correspond to bond purchases that equal 1% of the total bond market outstanding. For the four episodes, 1% of the market outstanding is $149 billion, $204 billion, $234 billion, and $336 billion, which corresponds to 9%, 34%, 15%, and 8% of the actual purchases, respectively. We apply these scaling factors to the estimated total contributions from different channels. For example, for QE1, we derive bond yield changes due to total investor flows during the episode, apply the scaling factor of 9%, and define the product as the contribution from investor flows to bond yield changes in response to QE1.

We focus on the first half of each QE episode to exclude changes in expectations of future policies. For example, during a congressional hearing in May 2013, which took place in the

middle of QE3, the Fed Chair disclosed the intention of tapering future asset purchases. This announcement led to large bond fund outflows and significant increases in bond yields, a phenomenon known as the "Taper Tantrum."

Figure 10 shows the results. The gray bars on the right indicate term spread changes attributable to decreases in the amount outstanding solely due to Fed purchases, while all other channels (e.g., investor AUM) are held constant at their values at the beginning of each episode. They show that, when the amount of bonds outstanding decreases by 1% due to Fed purchases, the term spread decreases by 26-32 bps. The magnitude depends on two factors: the specific assets purchased and aggregate investor elasticity. Investor elasticity is lower during crisis periods, leading to significant yield changes per unit of Fed purchase.

The other colored bars show contemporaneous yield changes attributable to, respectively, investor flows, demand for duration, changes in callable bond duration, and changes in the amount outstanding due to issuance and redemption. It is clear that the total effect of QE depends not only on the Fed's purchases themselves but significantly on the other channels we consider. When the Fed's purchases push down long-term yields, they can lead to return-chasing retail inflows to mutual funds and banks, an increase in the duration of insurance or pension liabilities, a shortening of the duration of callable bonds, and more bond issuance, similar to the effects of decreases in short-term interest rates. These changes in demand and supply, in turn, exert further pressure on bond yields.

The strengths of these channels vary considerably over the four episodes. For example, investor flows amplify rate declines by another 16 bps during QE1; this number drops to 7 and 8 for QE2 and QE3, and it soars to 32 for QE4. This is because: 1) investor elasticity is considerably smaller during crisis periods, and 2) inflows to bond mutual funds and banks were particularly large in 2009 and 2020. The results here echo our earlier findings with conventional monetary policy and emphasize the state dependency of how demand and supply channels respond to monetary policy.

In summary, we quantify yield changes attributable to different channels in response to direct bond purchases by the Federal Reserve. The direct effect from changes in the amount outstanding is small compared to the total effects resulting from changes in investor demand or issuer supply.

6 Conclusion

In this paper, we use portfolio holdings data to dissect the bond market transmission of monetary policy. We document several stylized facts regarding the transmission of monetary policy through investors' portfolios. In response to expansionary monetary policy, mutual funds increase bond purchases driven by capital inflows, insurance companies extend portfolio duration to hedge liabilities, and banks engage in both strategies to manage deposit inflows and counteract the duration shortening of mortgages. This additional investor demand reinforces the Fed's influence on long-term yields, acting as a "helping hand." The resulting excess demand is largely met by new issuance from the Treasury, mortgage borrowers, and corporations, while primary dealers play a more limited role.

We quantify the contribution of different institutions as well as net issuance to equilibrium bond yields using a random-coefficient asset demand system and estimate it using granular holding data. We find that flows to mutual funds and banks, changes in demand for credit ratings and duration, and changes in callable bond duration play significant roles in amplifying bond yield sensitivity to monetary policy. A large portion of these amplifications is absorbed by bond issuance, where government issuance can partially crowd out issuance by corporations and mortgage borrowers. The contribution of each channel is heterogeneous across the term structure and credit spectrum and is contingent on time-varying state variables such as investor composition and investor elasticity.

Our findings highlight the importance of the financial channels of monetary policy transmission. They suggest that the impact of monetary policy on bond markets is not solely determined by direct interest rate changes but is also shaped by the dynamic responses of different investor classes. The heterogeneity in investor behavior, combined with the interaction between portfolio adjustments and bond issuance, underscores the complexity of monetary policy's effects on financial markets. Future research could further explore how these mechanisms evolve under different macroeconomic conditions and regulatory environments, as well as their implications for financial stability and policy design.

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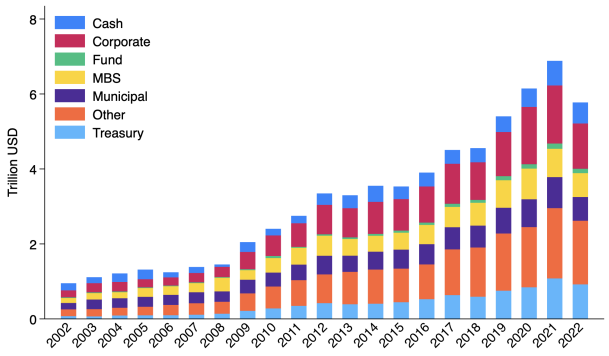
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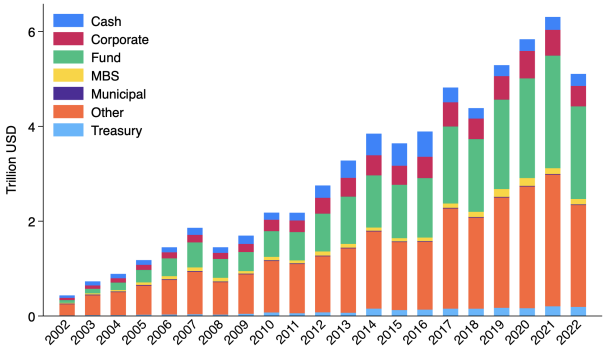
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Figure 1: **Investor Holdings.** The figures show holdings by the investors for which we have granular portfolio data: mutual funds and ETFs, insurance companies, banks, and the Federal Reserve.

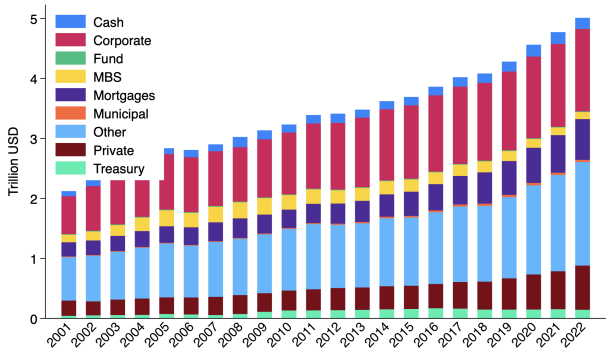
Panel A: U.S. Fixed Income Funds



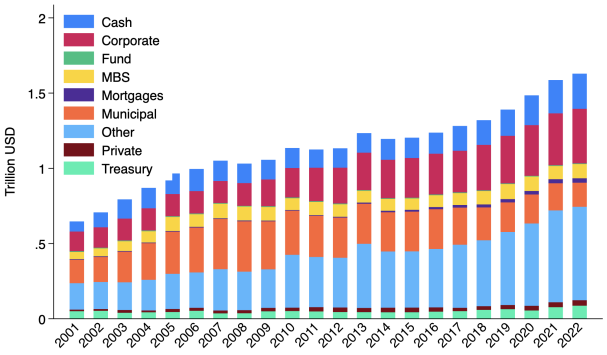
Panel B: Offshore and Allocation Funds



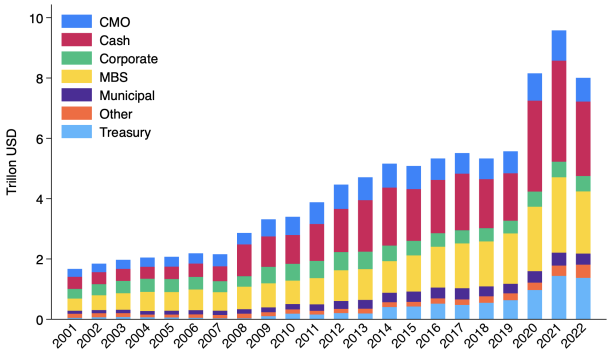
Panel C: Life Insurance Companies



Panel D: P&C Insurance Companies



Panel E: Banks (Securities Only)



Panel F: Federal Reserve

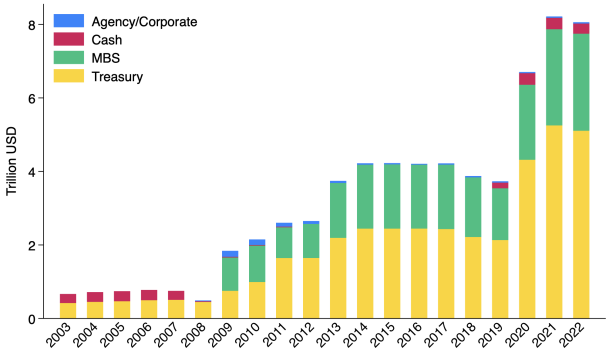
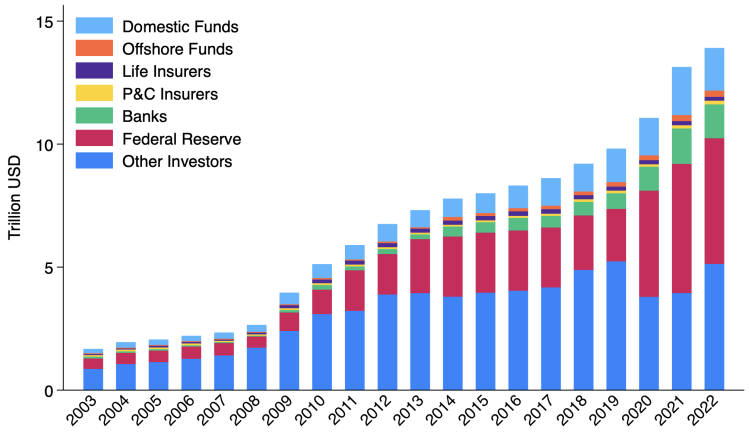
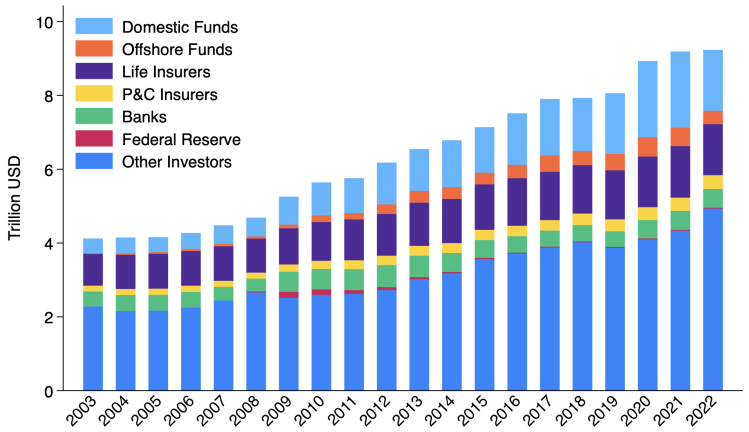


Figure 2: **Bond Ownership.** The figures show investor composition for Treasury bonds, corporate bonds, and agency MBS. We restrict to straight USD-denominated bonds (including callable bonds) with more than one year to maturity.

Panel A: Treasury Bonds



Panel B: Corporate Bonds



Panel C: Agency MBS

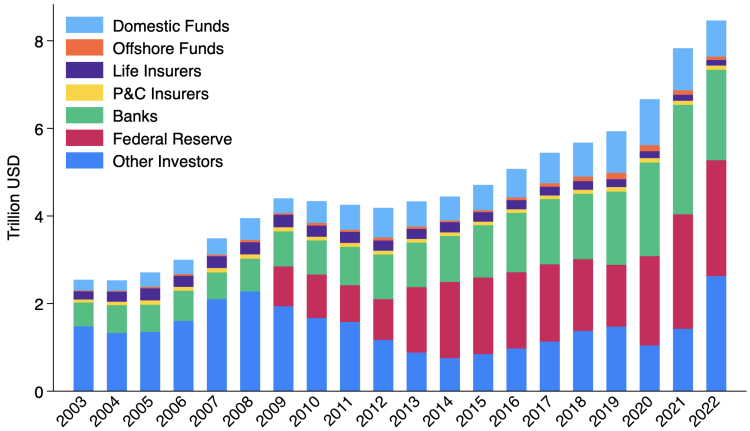
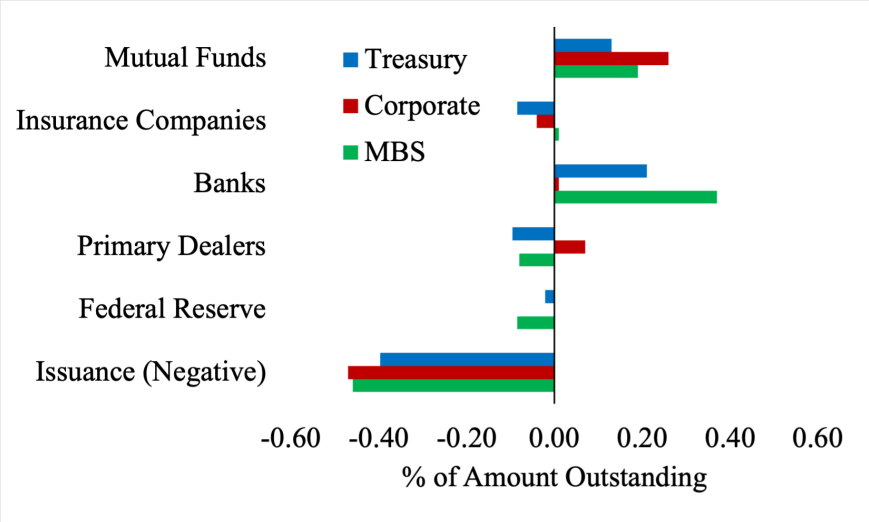
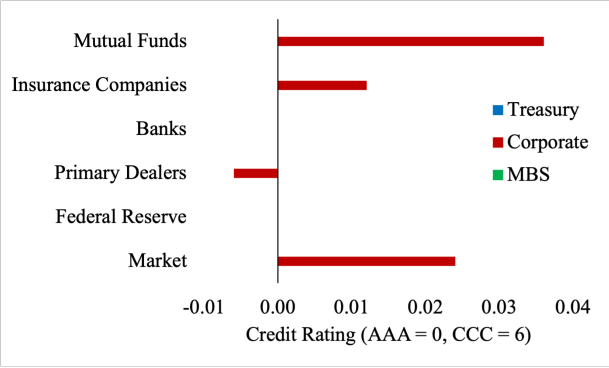


Figure 3: **Portfolio Changes to 100 bps Drop in One-year Treasury Rate.** These figures report $-\beta_1$ from the quarterly time series regression (1): $\Delta q_t = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \epsilon_t$ where Δq denotes change in holding amount (relative to amount outstanding), change in portfolio credit rating (AAA = 0, CCC = 6), or change in portfolio duration (year), r^{1Y} denotes one-year Treasury rate (%), and q^{FED} denotes Fed purchases (relative to amount outstanding). The regression is run separately for each investor group and for each bond class.

Panel A: Amount



Panel B: Credit Rating



Panel C: Duration

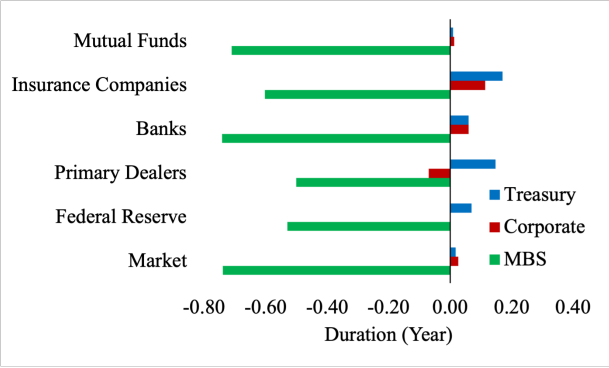
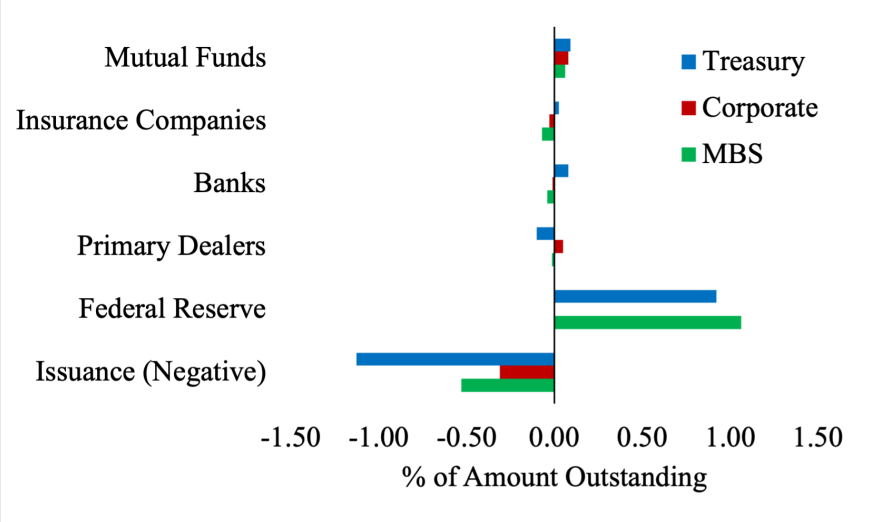
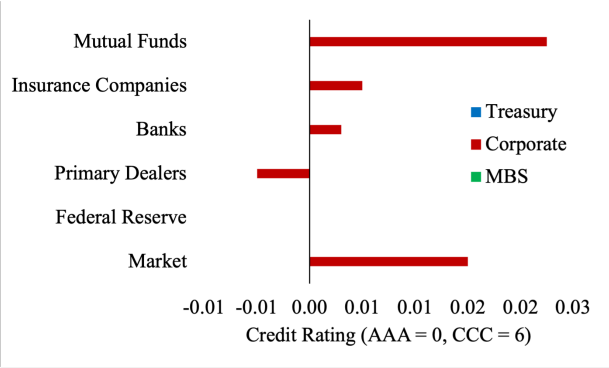


Figure 4: **Portfolio Changes to 1% Net Purchases by the Federal Reserve.** These figures report β_2 from the quarterly time series regression (1): $\Delta q_t = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \epsilon_t$ where Δq denotes change in holding amount (relative to total amount outstanding), change in portfolio credit rating (AAA = 0, CCC = 6), or change in portfolio duration (year), r^{1Y} denotes one-year Treasury rate (%), and q^{FED} denotes net purchases of Treasury bonds and MBS by the Federal Reserve (relative to total Treasury and MBS outstanding). The regression is run separately for each investor group and for each bond class.

Panel A: Amount



Panel B: Credit Rating



Panel C: Duration

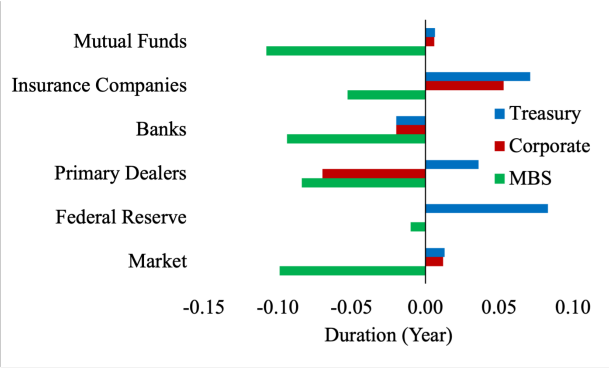
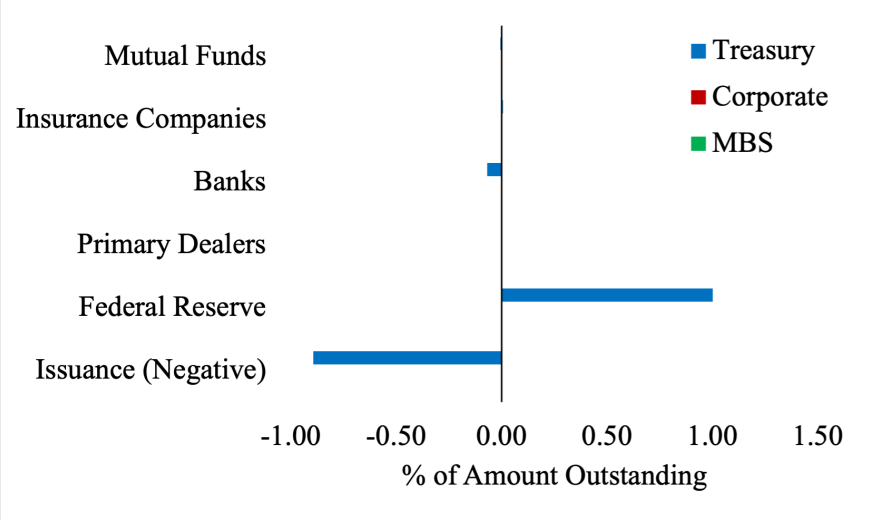


Figure 5: **Portfolio Changes across Bond Buckets.** These figures report β from the panel regressions (3) and (4) with maturity bucket-quarter observations: $\Delta q_{m,t} = \alpha + \beta \Delta q_{m,t}^{FED/PASSIVE} + \gamma_m + \gamma_t + \epsilon_{m,t}$ where Δq denotes net purchases by the investor (relative to amount outstanding), $q^{FED/PASSIVE}$ denotes net purchases by the Federal Reserve or by passive mutual funds (relative to amount outstanding), and γ_m and γ_t denote maturity bucket and time fixed effects. The regression is run separately for each investor group and for each bond class.

Panel A: Fed Purchase



Panel B: Flow-Induced Passive Purchase

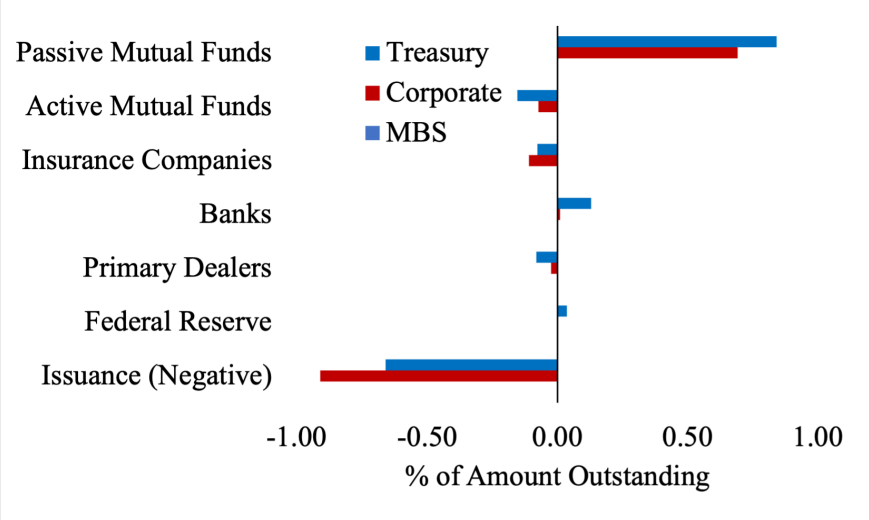
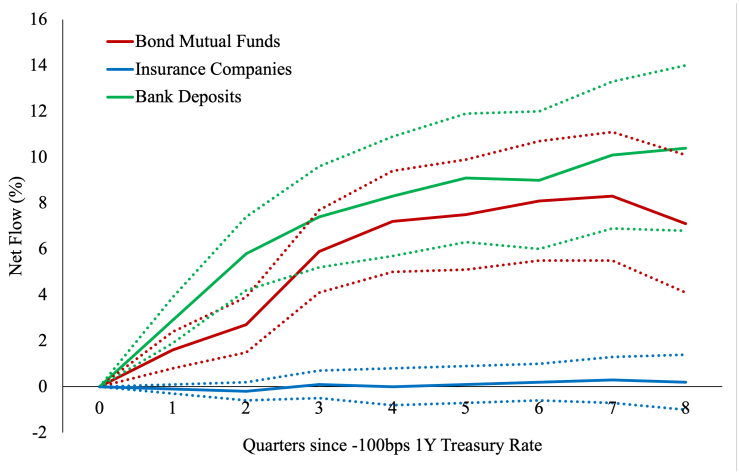


Figure 6: **Net Flow Response to Monetary Policy.** The figures show impulse responses of net flows of bond mutual funds, bank deposits and insurance companies to monetary policy, estimated as β_h from the following quarterly regression for different horizon h: $NetFlow_{t,t+h} = \alpha_h + \beta_{1,h}\Delta r_{t,t+1} + \beta_{2,h}\Delta q^{FED}_{t,t+1} + \epsilon_{t,t+h}$ Panel A shows, $\beta_{1,h}$, net flow responses to a -100 bps drop in the one-year Treasury rate. Panel B shows, $\beta_{2,h}$, net flow responses to 1% Fed purchases of Treasury bonds and MBS.

Panel A: Conventional Monetary Policy



Panel B: Unconventional Monetary Policy

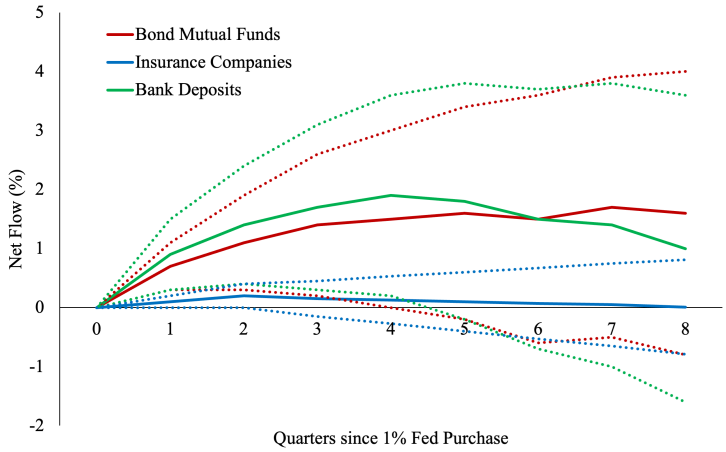
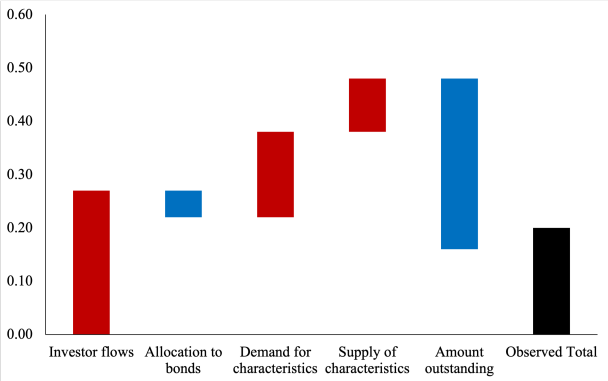
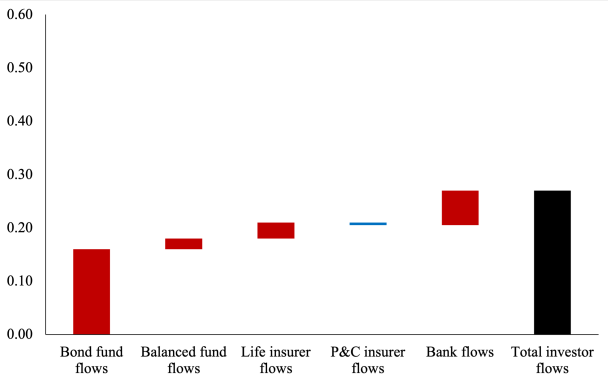


Figure 7: **10-Year Term Spread Sensitivity to Monetary Policy.** These figures show contributions from different channels to the monetary sensitivity of 10-year term spread according to our method described in Section 5.

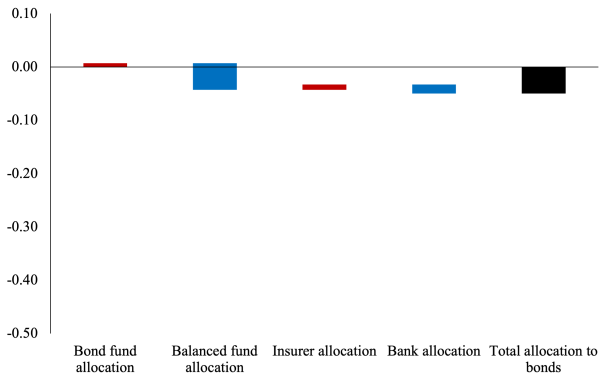
Panel A: All Channels



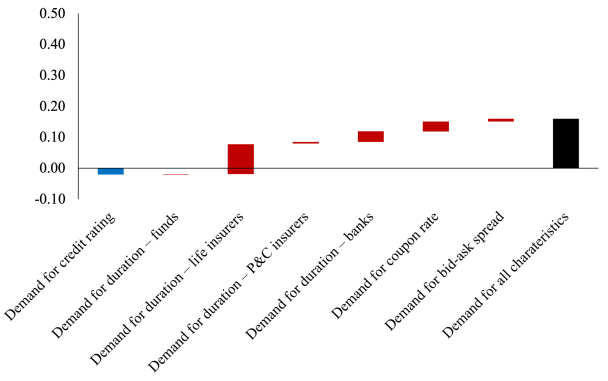
Panel B: Investor Flows



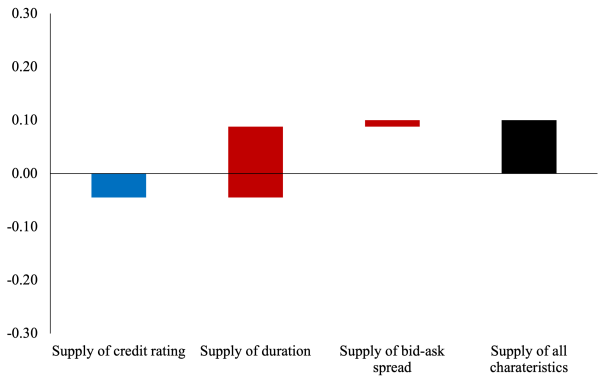
Panel C: Allocation to Bonds



Panel D: Demand for Characteristics



Panel E: Supply of Characteristics



Panel F: Amount Outstanding

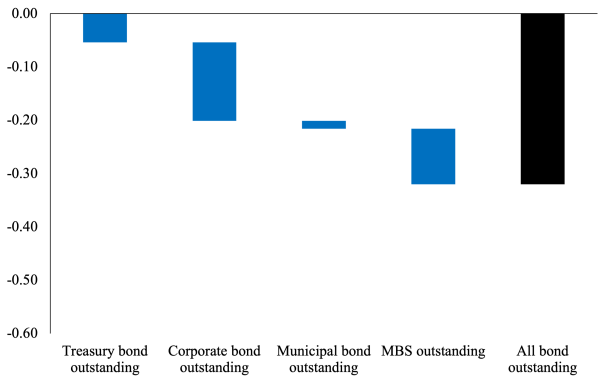
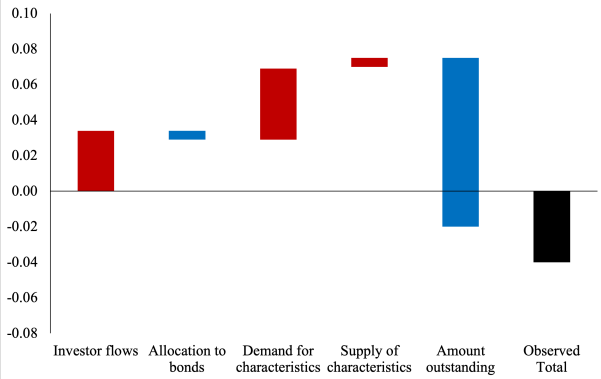
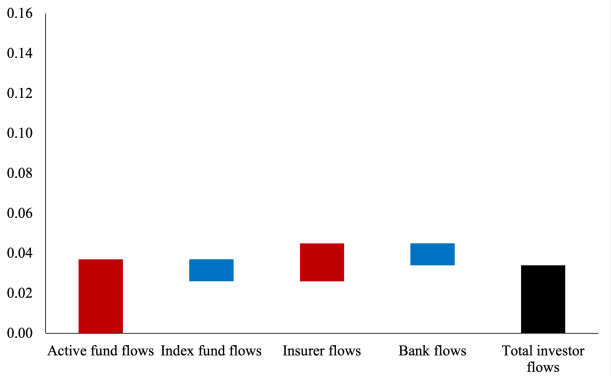


Figure 8: **10-Year BBB Spread Sensitivity to Monetary Policy.** These figures show contributions from different channels to the monetary sensitivity of 10-year BBB spread (over 10-year Treasury yield) according to our method described in Section 5.

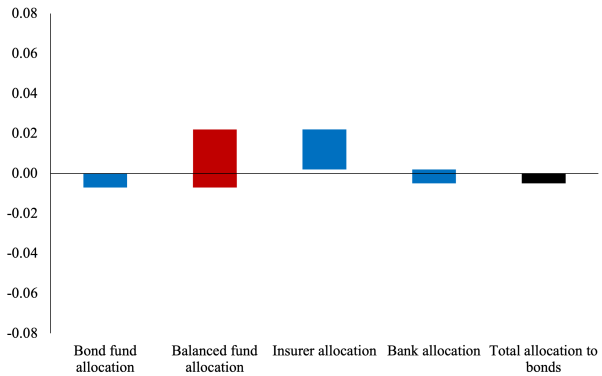
Panel A: All Channels



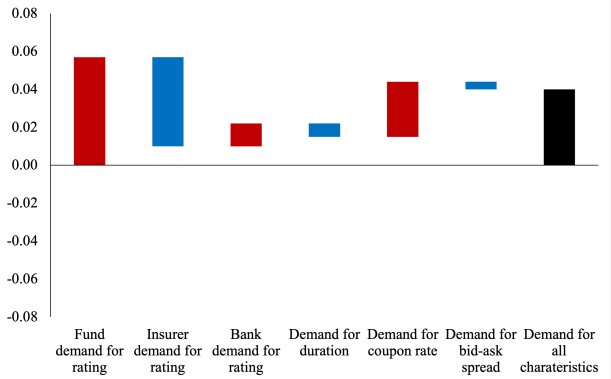
Panel B: Investor Flows



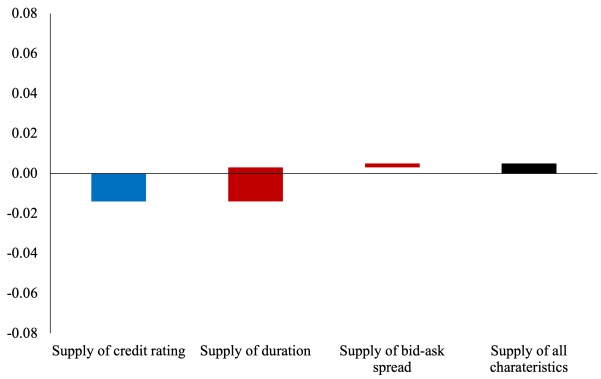
Panel C: Allocation to Bonds



Panel D: Demand for Characteristics



Panel E: Supply of Characteristics



Panel F: Amount Outstanding

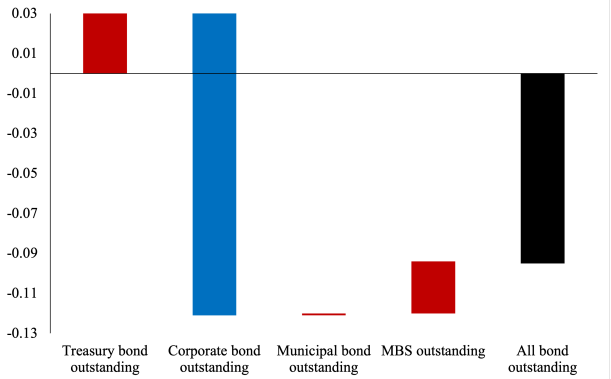
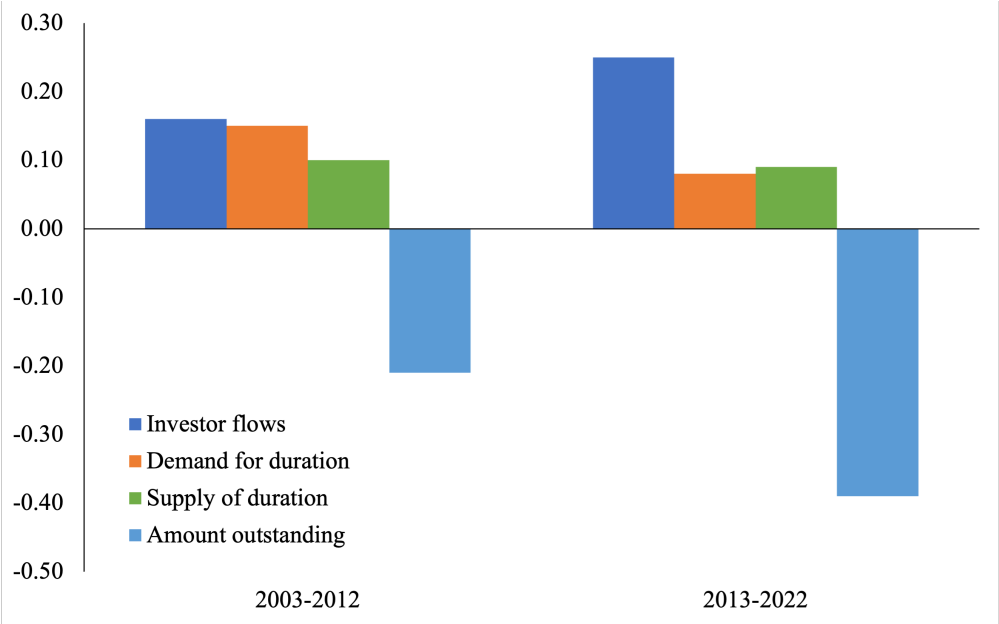


Figure 9: **The Evolution of Monetary Transmission over Time.** The figures show our estimated contributions from the top channels to monetary sensitivity of 10-year term spread (Panel A) and 10-year BBB credit spread (Panel B) in 2003-2012 versus in 2013-2022 according to our method described in Section 5.

Panel A: 10-Year Term Spread



Panel B: 10-Year BBB Spread

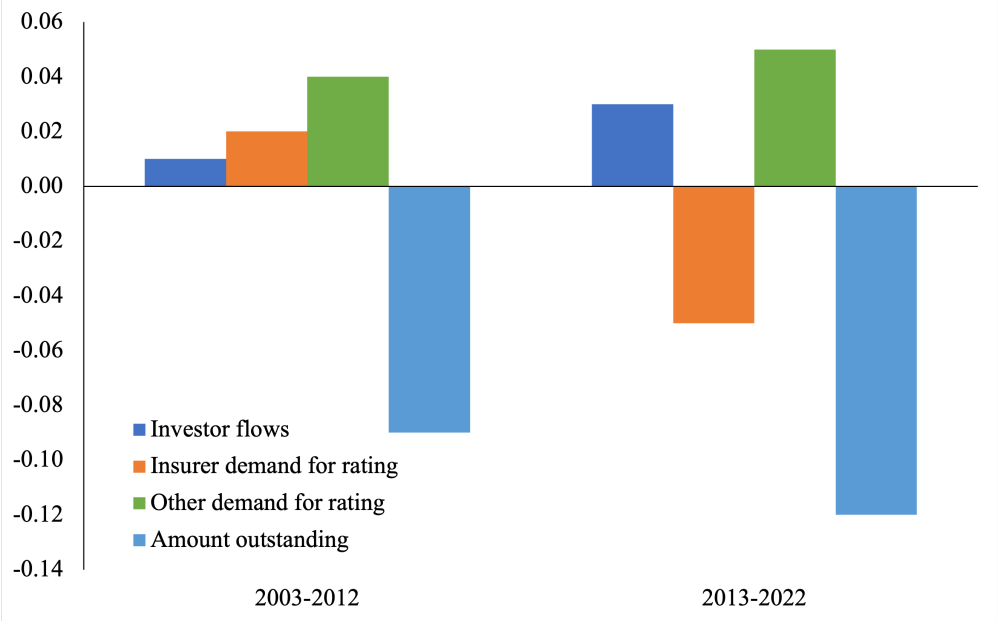
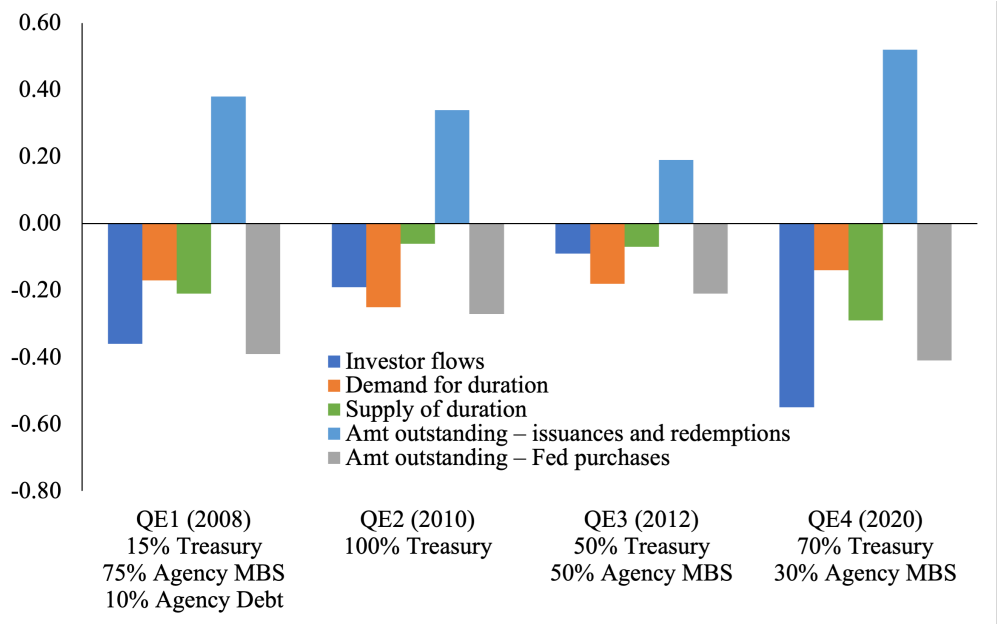


Figure 10: **Transmission of Quantitative Easing.** The figures show our estimated contributions of the top channels to 10-year term spread (Panel A) and 10-year BBB credit spread (Panel B) during each of the four quantitative easing episodes. All estimates are scaled so that the purchases are equal to 1% of total bond market outstanding.

Panel A: 10-Year Term Spread



Panel A: 10-Year BBB Spread

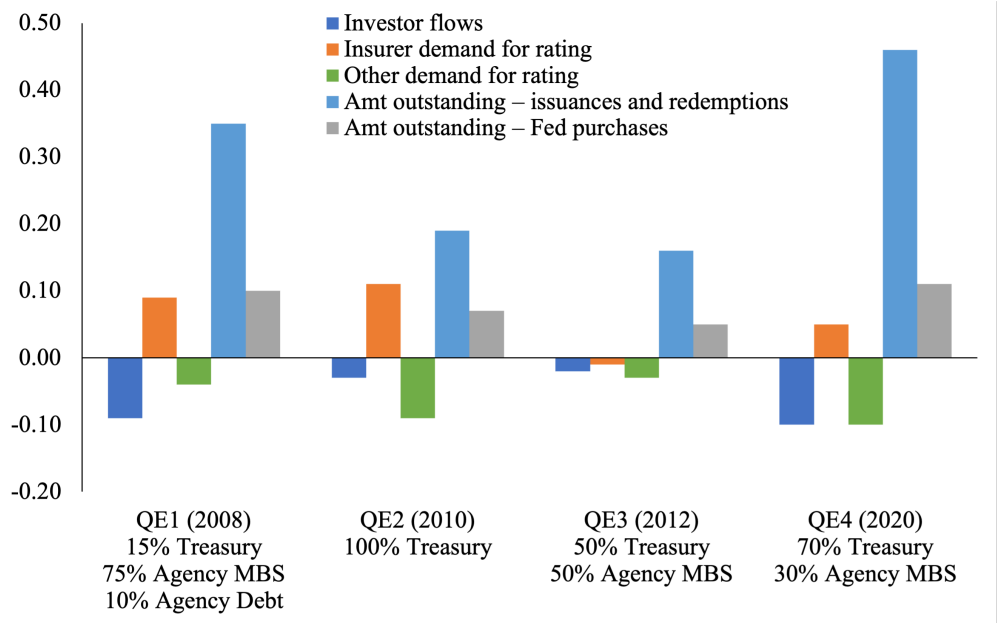


Table 1: **Bond Portfolio Summary Statistics.** This table shows summary statistics of our bond portfolios. Bond portfolios are formed by grouping together bonds that have similar credit rating, coupon rate, time to maturity and callability, separately for Treasury bonds, corporate bonds, municipal bonds, and agency MBS. The reported statistics include credit rating (ranging from 0 for AAA to 6 for CCC), duration (years), coupon rate (%), callability (0 or 1), bid-ask spread (%), and amount outstanding (billion USD). All statistics are calculated using amount outstanding as frequency weight.

	Mean	SD	P10	P50	P90
	538 Treasury Bond Portfolios				
Credit Rating	0.00	0.00	0.00	0.00	0.00
Duration	5.04	5.77	1.00	2.93	6.00
Coupon Rate	2.13	1.96	0.50	2.00	3.00
Callability	0.00	0.05	0.00	0.00	0.00
Bid-Ask Spread	0.04	0.03	0.02	0.04	0.05
Amount Outstanding	737	1217	90	236	772
	2132 Corporate Bond Portfolios				
Credit Rating	2.18	1.61	1.00	2.00	3.00
Duration	6.53	5.73	2.77	4.67	7.94
Coupon Rate	4.90	2.38	4.00	4.00	6.00
Callability	0.13	0.33	0.00	0.00	0.00
Bid-Ask Spread	0.49	0.56	0.20	0.34	0.55
Amount Outstanding	58	58	14	39	83
	1753 Municipal Bond Portfolios				
Credit Rating	1.22	0.86	1.00	1.00	2.00
Duration	9.39	5.83	4.54	8.71	13.59
Coupon Rate	5.19	1.71	4.00	6.00	6.00
Callability	0.72	0.45	0.00	1.00	1.00
Bid-Ask Spread	1.15	0.73	0.61	1.01	1.56
Amount Outstanding	14	12	4	11	19
	537 Agency MBS Portfolios				
Credit Rating	0.00	0.00	0.00	0.00	0.00
Duration	7.53	2.47	5.51	7.95	9.49
Coupon Rate	4.21	1.40	3.00	4.00	5.50
Callability	1.00	0.00	1.00	1.00	1.00
Bid-Ask Spread	0.06	0.03	0.04	0.06	0.07
Amount Outstanding	260	322	57	165	322

Table 2: **Estimated Own- and Cross-Price Elasticities.** These tables display estimated own- and cross- price elasticities according to Equation 10. The diagonal cells show average own-price elasticities for all bonds with the given rating or duration, across all periods and across all mutual funds (Panel A), insurance companies (Panel B), or banks (Panel C). The off-diagonal cell in row m and column n shows percent change in the holding of bond m with one-percent change price of bond n, averaged across all bond pairs with the given rating or duration combination, across all periods and across all mutual funds (Panel A), insurance companies (Panel B), or banks (Panel C).

Panel A: Mutual Funds

	AA	A	BBB	BB	B	CCC
AA	-2.42	2.59	1.28	0.11	0.31	0.01
A	1.21	-2.78	2.93	0.87	0.08	0.07
BBB	0.93	1.35	-4.03	2.04	1.49	0.03
BB	0.14	0.18	1.25	-1.96	1.22	1.02
B	0.28	1.27	0.02	2.98	-2.06	1.00
CCC	0.03	0.34	0.94	0.08	1.12	-1.58

	1-3Y	3-5Y	5-7Y	7-10Y	10-15Y	15-30Y
1-3Y	-3.12	2.01	1.98	0.34	0.53	0.54
3-5Y	3.23	-3.54	2.44	1.72	0.11	0.31
5-7Y	1.88	2.44	-4.72	2.90	1.03	0.82
7-10Y	1.32	0.29	1.92	-2.52	1.45	0.06
10-15Y	0.02	0.43	0.44	1.53	-1.27	1.03
15-30Y	0.11	0.03	0.44	0.36	1.34	-0.84

Panel B: Insurance Companies

	AA	A	BBB	BB	B	CCC
AA	-0.54	1.66	0.77	0.19	0.03	0.01
A	1.21	-1.01	1.42	0.42	0.26	0.07
BBB	0.93	0.89	-1.54	1.04	0.85	0.04
BB	0.14	0.14	1.76	-0.77	0.93	0.37
B	0.28	0.06	1.03	1.28	-0.29	0.43
CCC	0.03	0.01	0.02	0.08	1.12	-0.03

	1-3Y	3-5Y	5-7Y	7-10Y	10-15Y	15-30Y
1-3Y	-0.47	1.02	0.78	0.55	0.53	0.23
3-5Y	0.54	-1.04	1.54	1.03	0.11	0.01
5-7Y	0.88	0.59	-0.98	1.88	1.03	0.27
7-10Y	0.23	0.91	1.25	-1.24	1.46	1.23
10-15Y	0.05	0.20	1.03	1.96	-1.93	1.22
15-30Y	0.01	0.14	0.58	0.31	1.34	-0.92

Panel C: Banks

	AA	A	BBB	BB	B	CCC
AA	-2.14	1.52	1.46	0.26	0.72	0.03
A	0.67	-2.01	1.23	0.28	0.83	0.13
BBB	0.19	1.02	-1.02	0.39	0.97	0.48
BB	0.28	0.20	0.49	-1.34	1.43	0.08
B	0.06	0.40	1.02	0.41	-1.23	0.15
CCC	0.01	0.07	0.09	0.08	0.97	-0.77

	1-3Y	3-5Y	5-7Y	7-10Y	10-15Y	15-30Y
1-3Y	-3.22	2.05	0.93	1.05	0.28	0.02
3-5Y	2.32	-2.44	1.99	1.72	0.11	0.09
5-7Y	1.79	2.46	-1.49	2.24	1.03	0.43
7-10Y	1.03	1.25	2.03	-2.03	1.46	1.45
10-15Y	0.57	0.56	1.54	1.58	-3.17	1.03
15-30Y	0.11	0.18	0.43	0.45	1.34	-2.79

Table 3: **State Dependency of Monetary Transmission Channels.** The tables illustrate state dependency for each of the top channels through which monetary policy transmits to bond yields. For each channel, we quantify its contribution to 10-year term spread sensitivity to monetary policy given a range of 1) investor yield coefficients ($\{\alpha\}$, which govern price elasticities) on the vertical axis, and 2) the sensitivity of the underlying state variable to monetary policy. All other state variables are held constant at year-end 2022.

Panel A: Bond Fund Flow

		∂Bond Fund Flow / ∂1Y Treasury Rate				
		-4.0%	-6.0%	-8.0%	-12.0%	-16.0%
Yield Coeff	10th Pct	0.18	0.28	0.37	0.57	0.72
	25th Pct	0.14	0.20	0.26	0.33	0.50
	Median	0.11	0.15	0.20	0.30	0.42
	75th Pct	0.09	0.13	0.18	0.25	0.26
	90th Pct	0.05	0.09	0.13	0.19	0.25

Panel B: Insurer Demand for Duration

		∂Insurer Demand for Duration / ∂1Y Treasury Rate				
		-0.06	-0.09	-0.12	-0.16	-0.24
Yield Coeff	10th Pct	0.11	0.13	0.18	0.25	0.33
	25th Pct	0.07	0.12	0.15	0.21	0.28
	Median	0.05	0.06	0.08	0.11	0.15
	75th Pct	0.02	0.05	0.07	0.09	0.14
	90th Pct	0.01	0.03	0.04	0.09	0.10

Panel C: MBS Duration

		∂MBS Duration / ∂1Y Treasury Rate				
		0.10	0.15	0.20	0.30	0.40
Yield Coeff	10th Pct	0.11	0.17	0.20	0.30	0.39
	25th Pct	0.08	0.12	0.16	0.24	0.33
	Median	0.08	0.10	0.14	0.18	0.19
	75th Pct	0.08	0.09	0.11	0.15	0.21
	90th Pct	0.03	0.06	0.10	0.15	0.17

Panel D: Corporate Bond Outstanding

		∂Corporate Bond Outstanding / ∂1Y Treasury Rate				
		-2%	-3%	-4%	-6%	-8%
Yield Coeff	10th Pct	-0.16	-0.24	-0.33	-0.50	-0.66
	25th Pct	-0.11	-0.17	-0.23	-0.35	-0.46
	Median	-0.08	-0.13	-0.18	-0.26	-0.36
	75th Pct	-0.07	-0.11	-0.15	-0.22	-0.31
	90th Pct	-0.05	-0.08	-0.11	-0.16	-0.21

Table 4: **The Dependency of Monetary Transmission on Investor Composition.** The tables show our estimated monetary sensitivity of term spread (Panel A) and 5-year credit spread (Panel B) for different relative sizes of bond funds versus life insurers. All state variables are set to their year-end 2022 values and their responses to monetary policy are set to their means estimated using the whole sample period.

Panel A: Term Structure

	Relative Bond Ownership between Bond Funds vs Life Insurers				
	0.50	0.75	1.00	1.50	2.00
2Y	-0.06	0.03	0.11	0.20	0.28
5Y	0.03	0.11	0.20	0.33	0.41
10Y	0.13	0.16	0.18	0.22	0.25
15Y	0.07	0.08	0.08	0.09	0.10
20Y	0.05	0.02	-0.01	-0.03	-0.04
30Y	0.06	0.03	0.02	0.00	-0.02

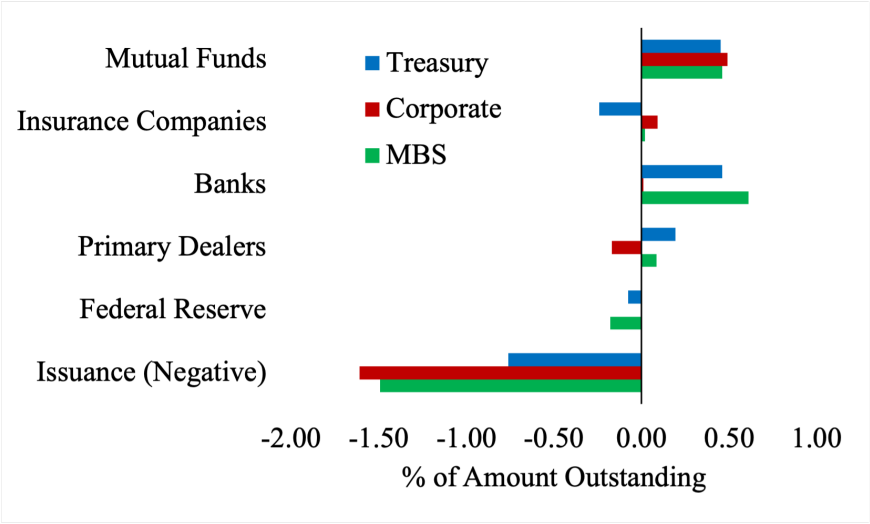
Panel B: Credit Spectrum

	Relative Bond Ownership between Bond Funds vs Life Insurers				
	0.50	0.75	1.00	1.50	2.00
AA	0.00	-0.01	-0.03	-0.04	-0.04
A	0.02	-0.01	-0.03	-0.04	-0.06
BBB	-0.10	-0.08	-0.05	-0.01	0.03
BB	-0.18	-0.15	-0.12	-0.07	-0.03
B	-0.11	-0.09	-0.09	-0.05	-0.02
CCC	-0.05	-0.04	-0.04	-0.02	0.00

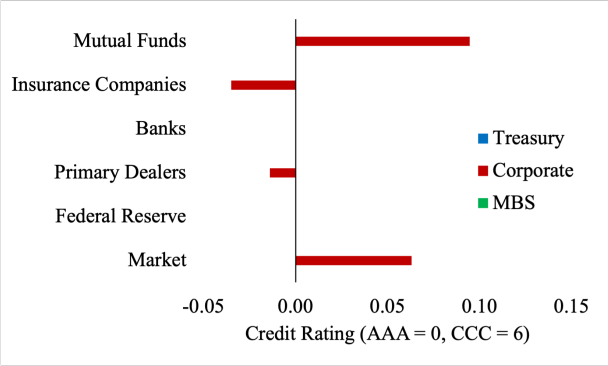
Appendix A Additional Figures

Figure A1: **Portfolio Changes to a -100 bps One-year Treasury Rate, Year over Year.** These figures report $-\beta_1$ from the following quarterly time series regression: $\Delta q_{t-4,t} = \alpha + \beta_1 \Delta r^{1Y}_{t-4,t} + \beta_2 q^{FED}_{t-4,t} + \epsilon_{t-4,t}$ where Δq denotes change in holding amount (relative to amount outstanding), change in portfolio credit rating (AAA = 0, CCC = 6), or change in portfolio duration (year), and r^{1Y} denotes one-year Treasury rate (%). The regression is run separately for each investor group and for each bond class.

Panel A: Amount



Panel B: Credit Rating



Panel C: Duration

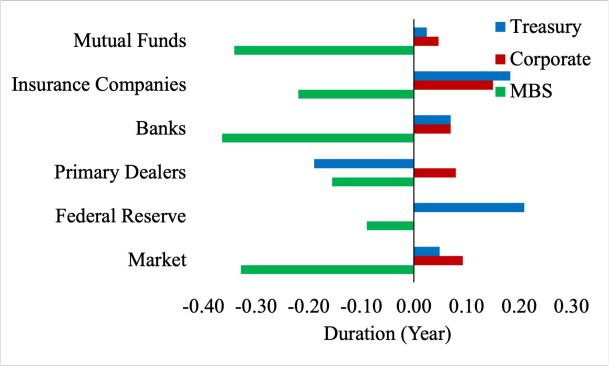
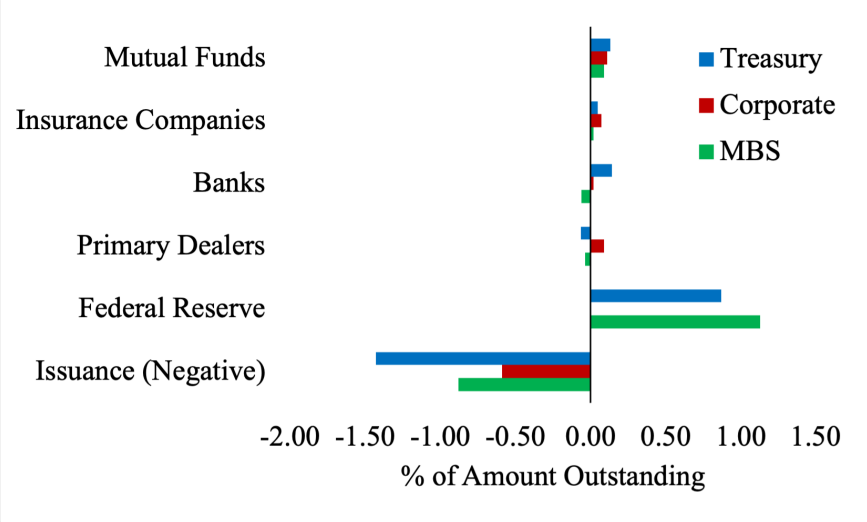
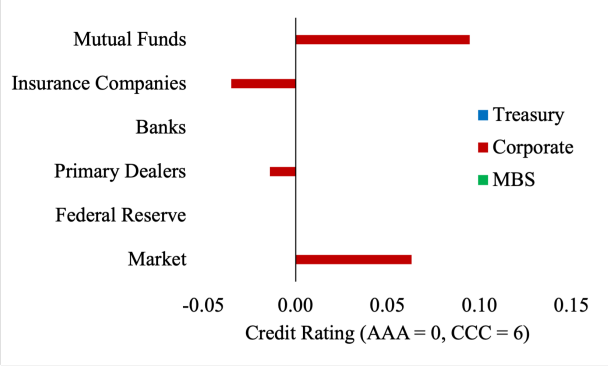


Figure A2: **Portfolio Changes to 1% Net Purchases by the Fed, Year over Year.** These figures report β_2 from the following quarterly time series regression: $\Delta q_{t-4,t} = \alpha + \beta_1 \Delta r^{1Y}_{t-4,t} + \beta_2 \Delta q^{FED}_{t-4,t} + \epsilon_{t-4,t}$ where Δq denotes change in holding amount (relative to total amount outstanding), change in portfolio credit rating (AAA = 1, CCC = 6), or change in portfolio duration (year), and q^{FED} denotes net purchases of Treasury bonds and MBS by the Federal Reserve (relative to total Treasury and MBS outstanding). The regression is run separately for each investor group and for each bond class.

Panel A: Amount



Panel B: Credit Rating



Panel C: Duration

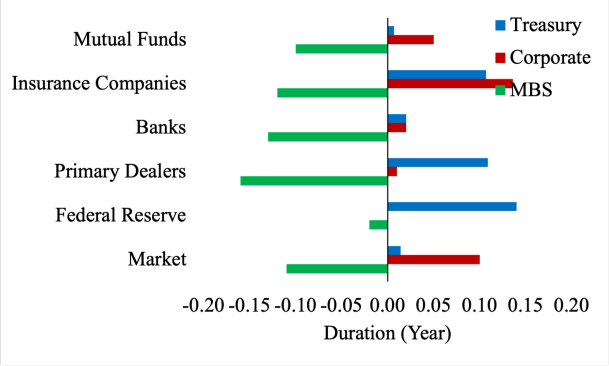
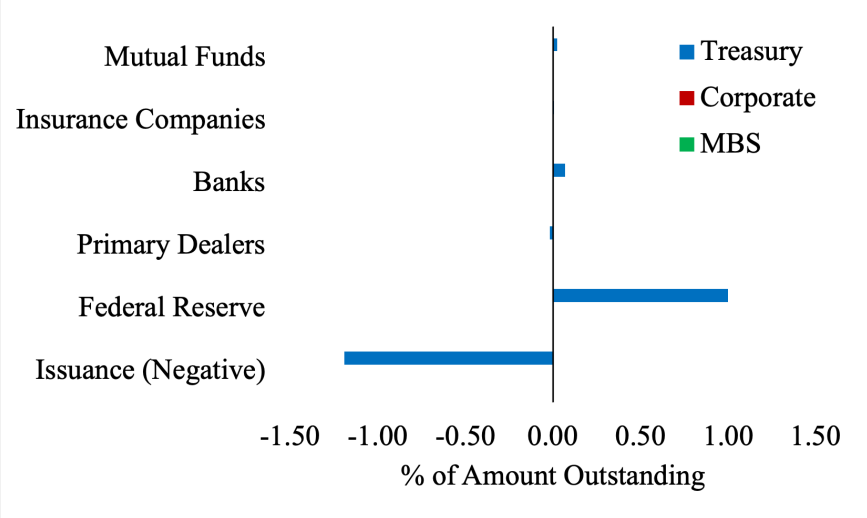


Figure A3: **Portfolio Changes with Time Fixed Effects, Year over Year.** These figures report β from the following panel regression with maturity bucket-quarter observations: $\Delta q_{m,t-4,t} = \alpha + \beta \Delta q^{FED/PASSIVE}_{m,t-4,t} + \gamma_m + \gamma_t + \epsilon_{m,t-4,t}$ where Δq denotes net purchases (relative to amount outstanding), q^{FED} denotes net purchases by the Federal Reserve or by passive mutual funds (relative to amount outstanding), and γ_m and γ_t denote maturity bucket and time fixed effects. The regression is run separately for each investor group and for each bond class.

Panel A: Fed Purchase



Panel B: Flow-Induced Passive Purchase

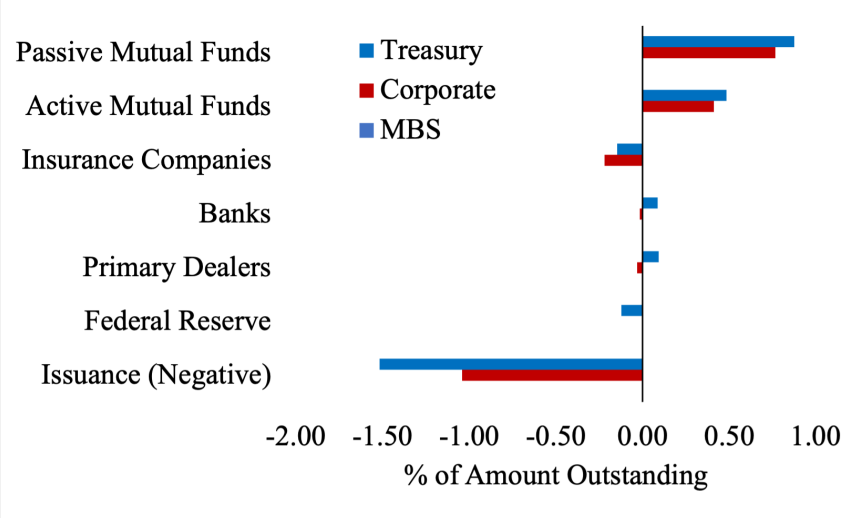
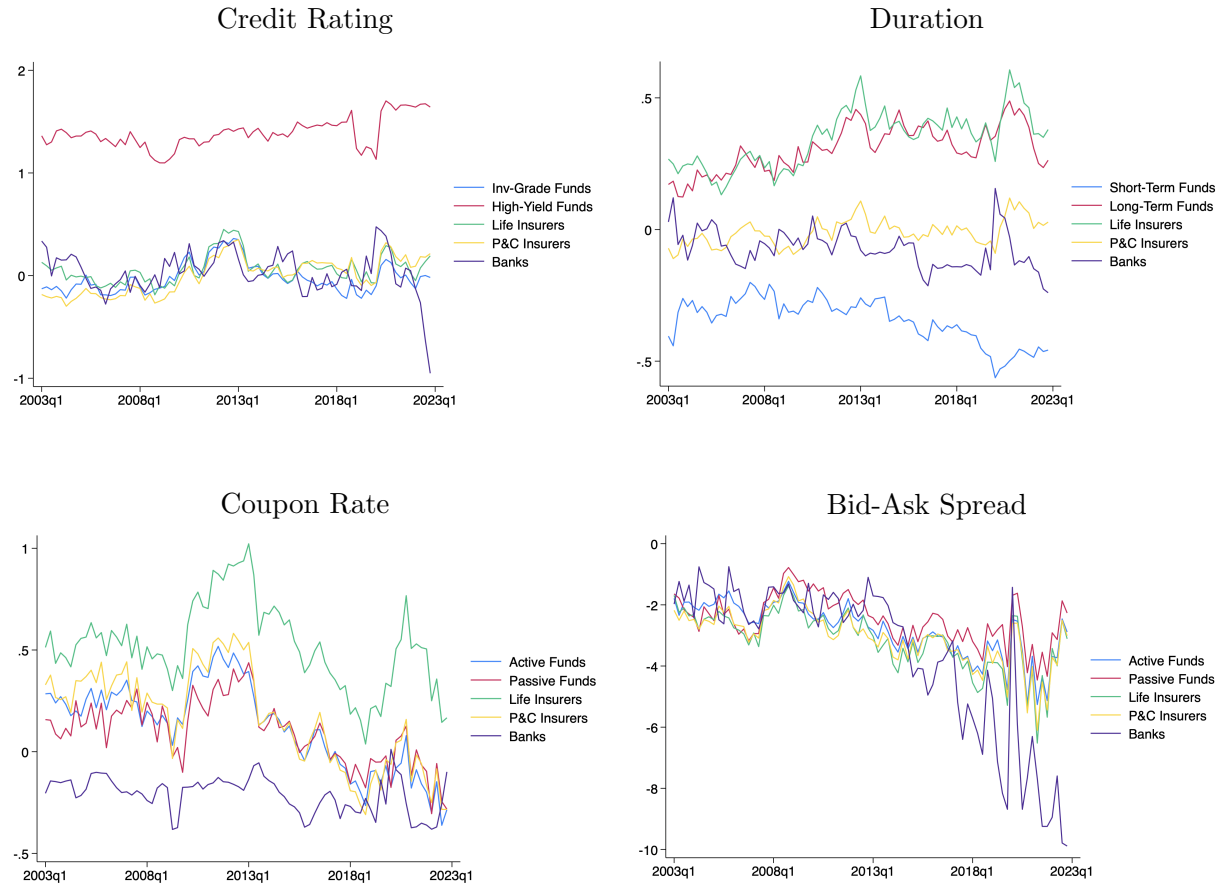


Figure A4: **Estimated Demand Coefficients.** These figures display estimated demand coefficients (μ, Σ) on credit rating (from 0 AAA to 6 CCC), duration (year), coupon rate (%), and bid-ask spread (%), using the procedures described in Section 4.4.

Panel A: Mean Coefficient μ



Panel B: Variation in Coefficient Σ

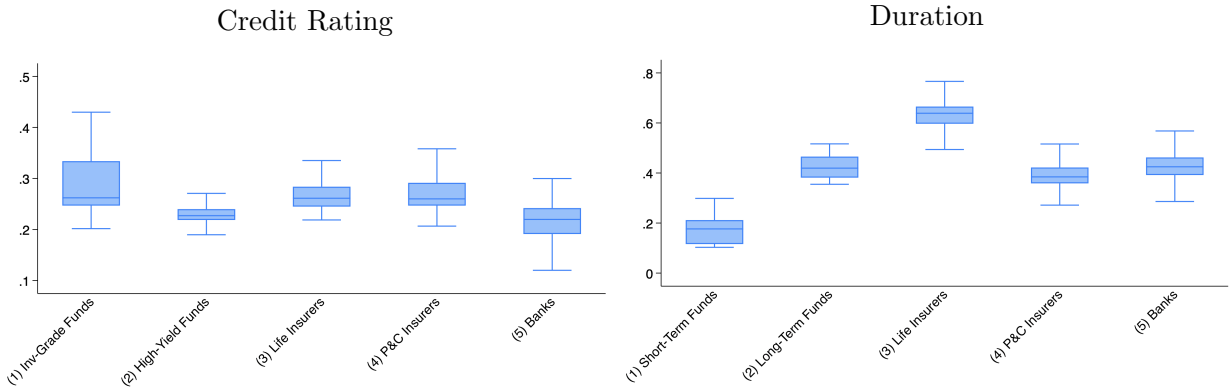
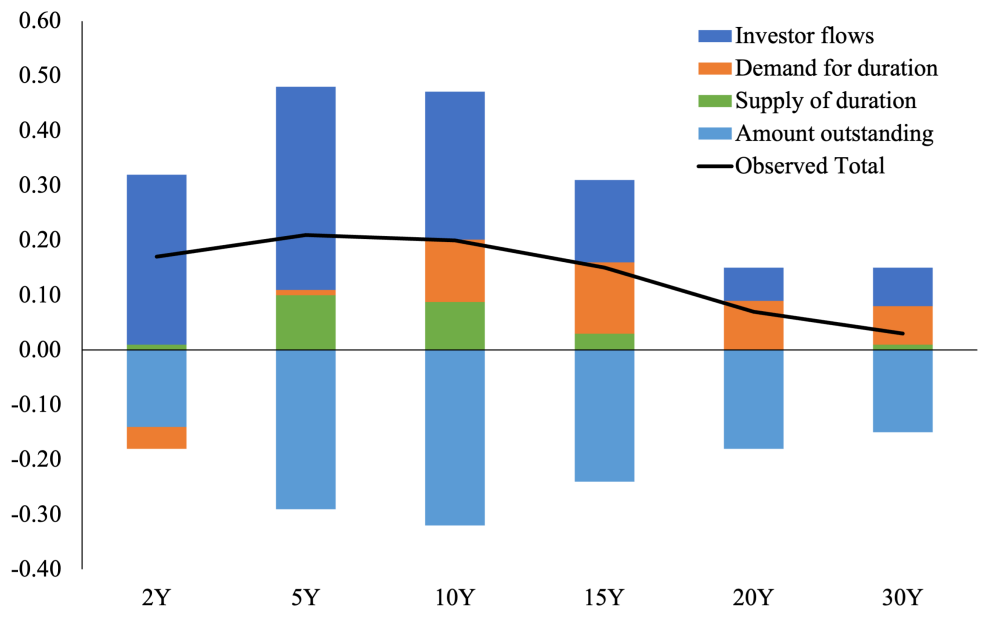


Figure A5: **Monetary Transmission across Term Structure and Credit Spectrum.** Panel A (Panel B) shows contributions from the top channels to the monetary sensitivity of 10-year term spread across different duration (5-year credit spread across different credit ratings), based on our method described in Section 5.

Panel A: Term Structure



Panel B: Credit Spectrum

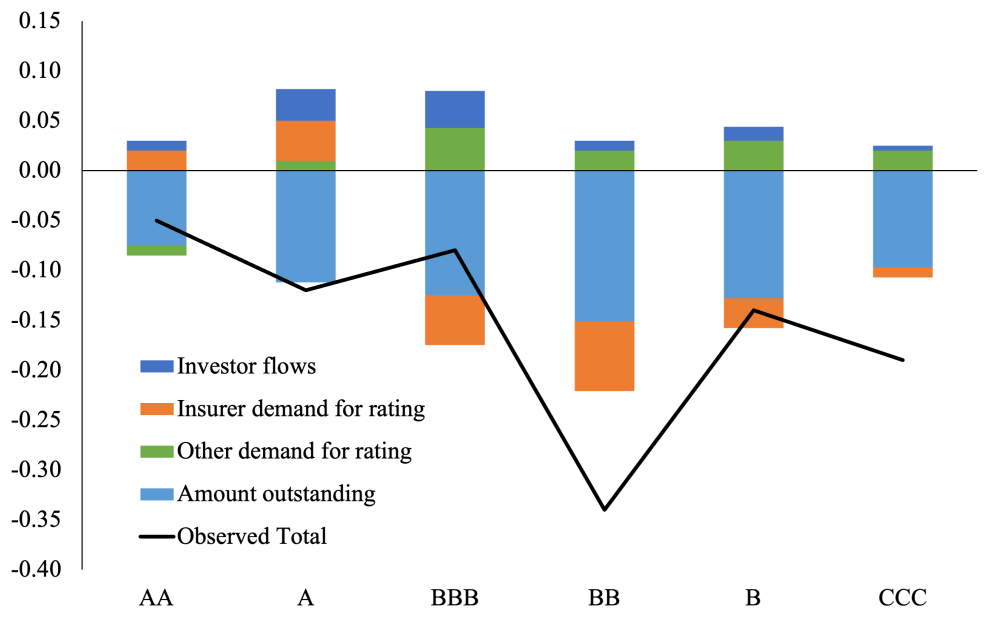
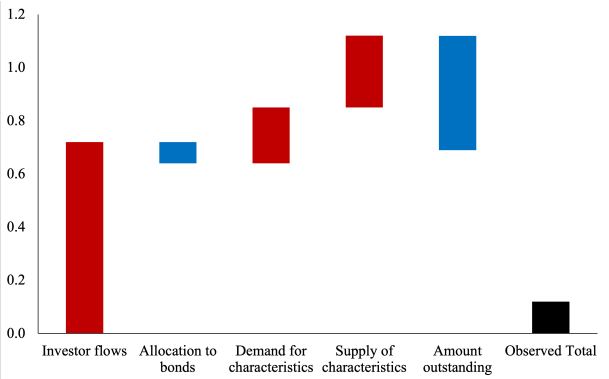
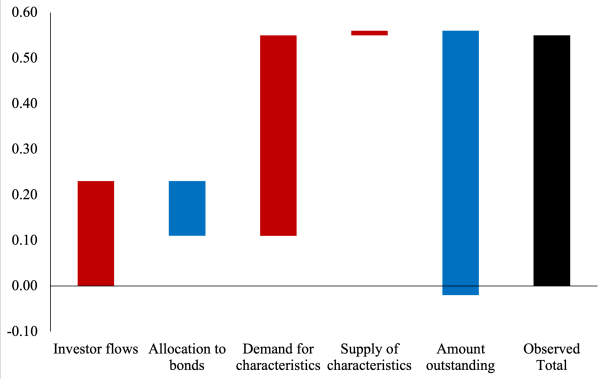


Figure A6: **Robustness with Monetary Policy Shocks.** The figures show decomposition of yield sensitivity with respect to monetary policy shocks constructed by Bu et al. (2021). Panel A (Panel B) shows the decomposition of the monetary sensitivity 10-year term spread (10-year BBB spread). Panel C (Panel D) shows the decomposition of the monetary sensitivity of term spread across duration (credit spread across ratings).

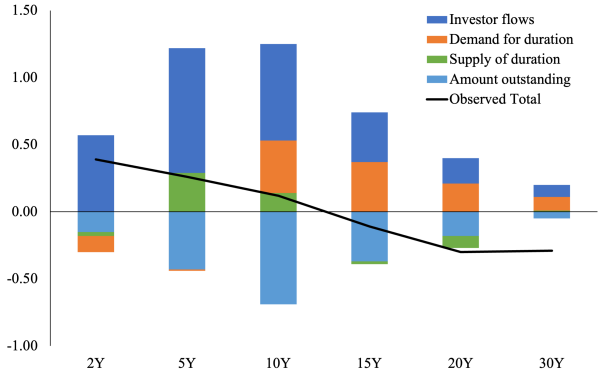
Panel A: 10-Year Term Spread



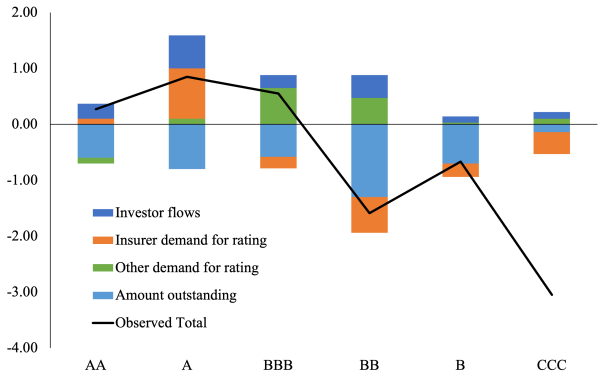
Panel B: 10-Year BBB Spread



Panel C: Term Structure



Panel D: Credit Spectrum



Appendix B Additional Tables

Table A1: **Flow-Induced Trading as Yield Instrument.** The tables examine the relevance of flow-induced trading (FIT, Equation 9) as instrument for bond yields. Specifically, they show the median t-statistic for $\tilde{\beta}$ for each investor type (Panel A) or each time segment (Panel B) from the following regression, run separately for each investor i at each time t: $y_{i,t}(n) = \tilde{\beta} FIT_{-i,t}(n) + \tilde{\gamma} Controls + \tilde{\epsilon}_{i,t}(n)$

Panel A: By Investor Type

Bond mutual funds	-6.43
Other mutual funds	-5.54
Life insurance companies	-7.07
P&C insurance companies	-6.58
Banks	-4.03

Panel B: By Time Segment

2003-2005	-4.72
2006-2008	-4.38
2009-2011	-7.23
2012-2014	-6.49
2015-2017	-6.01
2018-2020	-9.98
2021-2022	-6.36

Table A2: **Estimated Demand Coefficients.** This table shows estimated demand coefficients for our investor groups. There are 79 mutual fund groups (by Morningstar Category and by active vs passive), 20 insurance company groups (by life vs P&C and by size decile) and 10 bank groups (by size decile). The reported statistics include AUM (billion USD), mean coefficients (μ) for yield (%), credit rating (from 0 for AAA to 6 for CCC), duration (year), coupon rate (%) and bid-ask spread (%), and variation in coefficient (σ) for credit rating and duration.

Mutual Funds

	Mean	SD	P10	P50	P90
Bond AUM	45	84	0.1	12	123
Mean Coefficients (Mu)					
Yield	0.14	0.33	-0.48	0.24	0.73
Credit Rating	-0.04	1.13	-1.92	-0.01	1.36
Duration	0.03	0.21	-0.32	0.08	0.31
Coupon Rate	0.27	0.31	-0.29	0.04	0.41
Bid-Ask Spread	0.29	0.30	-0.29	0.27	0.41
Coefficient Variation (Sigma)					
Credit Rating	0.23	0.05	0.21	0.26	0.37
Duration	0.22	0.08	0.17	0.26	0.42

Insurance Companies

	Mean	SD	P10	P50	P90
Bond AUM	106	296	0.07	5	230
Mean Coefficients (Mu)					
Yield	-0.08	0.27	-0.19	0.01	0.41
Credit Rating	-0.39	0.73	-1.26	-0.51	0.65
Duration	0.04	0.19	-0.05	0.07	0.30
Coupon Rate	0.24	0.37	0.03	0.16	0.49
Bid-Ask Spread	0.21	0.44	-0.05	0.14	0.45
Coefficient Variation (Sigma)					
Credit Rating	0.26	0.03	0.23	0.26	0.32
Duration	0.49	0.09	0.33	0.49	0.63

Banks

	Mean	SD	P10	P50	P90
Bond AUM	351	1139	5	24	2971
Mean Coefficients (Mu)					
Yield	0.12	0.18	-0.03	0.11	0.29
Credit Rating	0.01	0.53	-0.70	0.01	0.73
Duration	-0.02	0.08	-0.11	-0.01	0.08
Coupon Rate	-0.15	0.10	-0.27	-0.14	-0.05
Bid-Ask Spread	-0.77	0.48	-1.34	-0.71	-0.24
Coefficient Variation (Sigma)					
Credit Rating	0.21	0.03	0.17	0.21	0.25
Duration	0.43	0.06	0.35	0.42	0.50

Table A3: **Estimated Own- and Cross-Price Elasticities, Fixed Coefficient Logit Model.** These tables are the counterparts of Table 2 but coefficient variation σ is set to zero. The diagonal cells show average own-price elasticities for all bonds with the given rating or duration, across all periods and across all mutual funds (Panel A), insurance companies (Panel B), or banks (Panel C). The off-diagonal cell in row m and column n shows percent change in the holding of bond m with one-percent change price of bond n, averaged across all bond pairs with the given rating or duration combination, across all periods and across all mutual funds (Panel A), insurance companies (Panel B), or banks (Panel C).

Panel A: Mutual Funds

	AA	A	BBB	BB	B	CCC
AA	-2.40	1.29	1.32	1.36	1.00	0.46
A	0.58	-2.72	1.41	1.34	1.02	0.51
BBB	0.70	1.24	-3.95	1.27	0.87	0.49
BB	0.62	1.24	1.31	-1.92	0.96	0.53
B	0.70	1.18	1.42	1.28	-1.99	0.60
CCC	0.58	1.27	1.46	1.22	0.93	-1.56

	1-3Y	3-5Y	5-7Y	7-10Y	10-15Y	15-30Y
1-3Y	-3.04	1.12	1.46	1.48	1.05	0.60
3-5Y	1.43	-3.51	1.53	1.57	1.02	0.59
5-7Y	1.42	1.19	-4.64	1.45	0.95	0.65
7-10Y	1.47	1.13	1.62	-2.45	0.96	0.72
10-15Y	1.41	1.04	1.58	1.48	-1.25	0.62
15-30Y	1.45	1.05	1.64	1.56	1.03	-0.79

Panel B: Insurance Companies

	AA	A	BBB	BB	B	CCC
AA	-0.51	0.73	1.19	0.71	0.72	0.22
A	0.59	-0.95	1.18	0.74	0.73	0.30
BBB	0.66	0.56	-1.54	0.68	0.68	0.32
BB	0.61	0.69	1.03	-0.71	0.73	0.35
B	0.64	0.74	1.03	0.70	-0.27	0.36
CCC	0.70	0.72	1.16	0.73	0.70	-0.04

	1-3Y	3-5Y	5-7Y	7-10Y	10-15Y	15-30Y
1-3Y	-0.44	0.59	1.15	1.22	0.96	0.78
3-5Y	0.37	-0.98	1.14	1.18	1.06	0.64
5-7Y	0.37	0.60	-0.91	1.32	0.97	0.77
7-10Y	0.37	0.75	1.09	-1.19	0.90	0.73
10-15Y	0.51	0.65	1.12	1.16	-1.83	0.65
15-30Y	0.41	0.58	1.16	1.24	0.96	-0.85

Panel C: Banks

	AA	A	BBB	BB	B	CCC
AA	-2.12	0.67	1.05	0.35	1.07	0.24
A	0.28	-1.93	0.93	0.42	1.15	0.33
BBB	0.43	0.80	-1.00	0.38	1.08	0.23
BB	0.33	0.69	1.02	-1.24	1.07	0.21
B	0.32	0.75	1.00	0.38	-1.14	0.27
CCC	0.40	0.71	0.96	0.47	0.99	-0.73

	1-3Y	3-5Y	5-7Y	7-10Y	10-15Y	15-30Y
1-3Y	-3.14	1.31	1.57	1.47	0.91	0.70
3-5Y	1.25	-2.41	1.52	1.57	0.88	0.64
5-7Y	1.25	1.48	-1.41	1.47	1.03	0.72
7-10Y	1.34	1.41	1.53	-2.02	0.98	0.77
10-15Y	1.34	1.35	1.57	1.52	-3.08	0.76
15-30Y	1.16	1.34	1.42	1.46	0.94	-2.75

Table A4: **Estimated Price Elasticity of Net Issuances.** The table shows price elasticities of the net issuance of Treasury bonds, corporate bonds, municipal bonds and MBS. We run the following regression, separately for each class of bonds: $\Delta \log S_t(n) = \tilde{\alpha} \widehat{\Delta \log P_t(n)} + \tilde{\beta}' x_t(n) + \tilde{\epsilon}_t(n)$ where, for each bond portfolio n, $\Delta \log S_t(n)$ denotes log change in amount outstanding, $\widehat{\Delta \log P_t(n)}$ change in price instrumented with contemporaneous flow-induced trading (Equation 9), and $x_t(n)$ bond characteristics including credit rating, duration, coupon rate, callability and bid-ask spread. t-statistics are reported in parentheses. *, **, and *** denote p-values less than 0.10, 0.05, and 0.01, respectively.

	Δlog(S)			
	Treasury	Corporate	Municipal	MBS
	(1)	(2)	(3)	(4)
Instrumented Δlog(P)	0.613***	0.437***	0.117	0.226***
	(3.336)	(3.793)	(1.257)	(4.447)
Credit Rating (log)		0.011***	-0.007*	
		(7.308)	(-1.746)	
Duration (log)	0.008	0.013***	0.053***	0.063***
	(1.353)	(11.094)	(9.477)	(19.835)
Coupon Rate (%)	-0.014***	-0.002***	-0.017**	-0.007
	(-16.401)	(-3.825)	(-2.341)	(-1.365)
Callability	0.012	-0.053***	-0.049***	
	(1.119)	(-12.709)	(-6.779)	
Bid-Ask Spread (%)	-0.359	0.003***	0.861**	0.000
	(-1.311)	(4.241)	(3.011)	(0.419)
Quarter Fixed Effects	Y	Y	Y	Y
Standard Errors	clustered by quarter			
Observations	6866	37697	78673	19108
R2	0.094	0.107	0.062	0.098