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

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Abstract

We use granular portfolio holdings data on major U.S. bond investors to examine the transmission of monetary policy. When the Federal Reserve conducts expansionary monetary policy, mutual funds increase their bond purchases due to retail inflows; insurance companies lengthen portfolio durations to hedge liabilities; and banks engage in both activities to accommodate deposit inflows and counteract the shortening of MBS duration. This elevated demand acts as a "helping hand," amplifying the Fed's impact on long-term yields. Most of the amplifying demand is absorbed by new bond issuances, while dealers play a limited role. Using an asset demand system framework, we show that investor demand explains a large share of the excess sensitivity of long-term yields. Meanwhile, bond issuance has become increasingly elastic in recent years, which explains the decline in yield sensitivity at low frequency. Overall, the "helping hand" effect of monetary policy is three times as important as changes in risk-free rates in driving corporate bond issuance.

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. In response to a 100 bps decrease in 1-year yields, textbook macro models predict roughly a 21 bps reduction in 10-year yields; however, the actual response averages around 71 bps on FOMC announcement days, more than three times of the theoretical prediction.[1] Similarly, unconventional monetary policies such as quantitative easing (QE) have a much greater impact on long-term interest rates than predicted by textbook macroeconomic theories.[2] In other words, monetary policy appears "too powerful". Former Fed governor Jeremy Stein highlighted this puzzle in a 2013 speech, asking, "How, in a world of eventually flexible goods prices, is monetary policy able to exert such a powerful influence on long-term real rates?"

Adding complexity to this puzzle, the excess sensitivity of long rates largely reverses at lower frequencies, especially in recent decades (Hanson, Lucca, and Wright, 2021). This reversal is interpreted as evidence that the excess sensitivity is transitory and therefore has limited significance for understanding the broader macroeconomic impact of monetary policy. Hanson et al. (2021) writes: "Our findings suggest that the recruitment channel may not be as strong as Stein (2013) speculates since a portion of the resulting shifts in term premia are transitory." Similarly, QE has large yield impacts on announcement days, but these impacts tend to diminish or revert over time.[3]

Existing empirical analyses have primarily focused on asset prices. Nevertheless, financial media frequently report that investors closely monitor monetary policy and actively adjust their portfolios in response. This observation motivates us to study how investor portfolios

[1]See Gürkaynak, Sack, and Swanson (2005), Hanson and Stein (2015), Gertler and Karadi (2015), Brooks, Katz, and Lustig (2018), and Bauer and Swanson (2023).

[2]See Greenwood, Hanson, and Vayanos (2023); Krishnamurthy and Vissing-Jorgensen (2011); D'Amico, English, López-Salido, and Nelson (2012); Swanson (2021); Selgrad (2023); Haddad, Moreira, and Muir (2024).

[3]For example, in response to the announcement of QE expansion on March 18th, 2009, 10-year Treasury yield fell by 51 bps on the same day. However, by the end of 2009, 10-year Treasury yield has *increased* by 87 bps relative to before the announcement.

change in response to monetary policy. In this paper, we construct a comprehensive dataset of granular portfolio holdings from major bond investors: mutual funds, insurance companies, banks, primary dealers, and the Federal Reserve. The dataset includes 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 observations of portfolio positions from 20,595 investors between 2003 and 2022. By the end of our sample period, these observations represent nearly $40 trillion in bond holdings.

We begin with a set of new stylized facts regarding investor portfolio adjustments following conventional and unconventional monetary policy actions. When there is a 100 bps cut in the short-term interest rate over a one-year horizon, mutual funds and banks expand their bond holdings by 0.41% and 0.43% of total market size in the same year, acting as a "helping hand" that amplifies the Fed's intervention. This demand expansion is enormous — equivalent to 1.4% of annual GDP.[4] This effect arises because both institutions experience significant retail inflows from households, expanding their balance sheets by 8–10%.

When mutual funds and banks purchase more bonds following a rate cut, who sells so that the market clears? Existing literature emphasizes the role of dealers as liquidity providers.[5] However, in practice, primary dealers are too small to absorb large quantities of demand induced by monetary policy. Instead, the amplifying demand is mostly met through new issuances by the Treasury Department, mortgage borrowers, and corporations: they issue more or repurchase fewer bonds totaling 0.90% of market outstanding, matching the magnitude of purchases from mutual funds and banks.

Investors adjust not only the size of their portfolios but also their composition. Following a rate cut, banks increase the duration of their Treasury and corporate bond holdings, as heightened prepayment probabilities shorten the duration of their MBS holdings. Insurance

[4]As of 2022, the total fixed income market is $46.2 trillion. The U.S. annual GDP was $26.0 trillion in 2022.

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

companies additionally extend their portfolio duration to hedge against the duration increase in their liabilities, which also feature convexity. Regarding credit risk, mutual funds shift toward holding more lower-rated bonds, while the opposite is true for insurers. These portfolio patterns have important implications for the pricing of duration and credit risks in the cross-section of bonds.

We find similar patterns for unconventional monetary policy, where the Fed directly purchases Treasury bonds and MBS. Mutual funds and banks, once again experiencing retail inflows, purchase more bonds that amplify the declines in long-term yields. Specifically, for each unit of bond purchased by the Fed, mutual funds and banks purchase another 0.5 unit of bond. These purchases by the Fed, mutual funds, and banks are almost entirely absorbed by new issuances, with dealers playing a limited role. 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 a demand-based asset pricing framework to quantify the impact of investor demand shifts as well as net issuances on equilibrium bond yields. In the model, investors exhibit heterogeneous preferences for bond characteristics such as credit rating and duration, reflecting their investment mandates or 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 are evaluated by counterfactually altering the relevant demand and supply parameters.

To capture the complex portfolio substitution behavior induced by monetary policy, we depart from standard logit demand models, which assume that investors adjust their portfolios proportionally across all other assets in response to changes in the price or characteristics of a given asset.[6] This proportional substitution fails to capture the observed tendency

[6]Nest logit models also assume proportional substitution within nests.

of banks and insurers to tilt toward long-term bonds when rates fall. We borrow insights from the industrial organization literature and introduce random coefficients into the asset demand framework, which relaxes the proportionality assumption. 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).

The estimated demand system shows that elevated asset demand following expansionary monetary policy explains a large portion of the excess yield sensitivity puzzle. Specifically, bond fund flows, bank deposit flows, and insurers and banks' duration demand serve as the primary amplifiers of yield sensitivity. The model further shows that net bond issuance by the Treasury Department, mortgage borrowers, and corporations absorbs significant investor demand, helping to explain why long-term yields appear less sensitive to monetary policy at lower frequencies. Overall, the "helping hand" effect of monetary policy is approximately three times more influential than changes in risk-free rates in driving bond issuance. This finding underscores the financial system's critical role in shaping the effectiveness of monetary policy.

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 bond fund flows on yield sensitivity to monetary policy has increased over time. On the other hand, net issuances, particularly by corporations and mortgage borrowers, have become more elastic over time. In the most recent monetary tightening episode from 2021 to 2023, net issuances fell by almost twice as much as during the tightening episode from 2003 to 2006. Our results shed light on the secular decline of yield sensitivity over time (Hanson et al., 2021). 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 is 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 banks and insurance companies, both of which further push down bond yields. Net issuance increases bond yields and largely reverses the combined effects of the Fed and other investors on asset prices. The dampening effects of net issuance help explain why the effects of QE are concentrated on announcement dates but revert over time (D'Amico and King, 2013). Our findings underscore that understanding monetary transmission requires going beyond yield changes and examining shifts in bond supply by the real sector.

1.1 Related Literature

This paper first contributes to the literature on monetary policy transmission to long-term rates (Gürkaynak et al., 2005; Hanson and Stein, 2015; Gertler and Karadi, 2015; Brooks et al., 2018; Hanson et al., 2021). This literature features twin puzzles: monetary policy appears overly powerful in the short run in affecting long-term yields, yet this effect reverses in the long run. These twin puzzles create potentially conflicting policy implications. On the one hand, the short-run excess sensitivity of long-term yields suggests that monetary policy may be excessively potent relative to standard macroeconomic models, potentially causing policy recommendations based on such models to overshoot their targets. On the other hand, the long-run reversal implies that this powerful effect might be merely transitory, possibly limiting its broader economic impact. A contribution of our study is to address these puzzles using asset quantity data. We demonstrate that the short-run excess sensitivity arises due to the "helping hand" of investors, and the long-run reversal occurs because of increasingly elastic bond issuance responses over time. This paper also contributes to the debate on the validity of event-study methodologies in the macro-finance literature. Although these methodologies have become increasingly popular as identification strategies (Gertler and Karadi, 2015; Nakamura and Steinsson, 2018), discrepancies between high- and low-frequency studies raise concerns that they may yield biased estimates of the longer-run impacts of macroeconomic news (Hanson et al., 2021). We show that leveraging asset quantity data can complement these studies by clarifying whether observed impacts on asset prices are truly transitory or have translated into meaningful quantity adjustments.

This paper also contributes to the literature that studies the impact of monetary policy on financial institutions. Some studies find that lower interest rates encourage institutions to reach 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 strand of literature studies 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; Fang, 2023; Darmouni, Siani, and Xiao, 2024). Our paper advances this literature by compiling a comprehensive dataset of portfolio holdings across the largest bond investors, allowing us to use a quantity-based approach to empirically quantify the relative importance of these channels.

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, Levinsohn, and Pakes, 1995). This flexibility is essential us to capture key transmission channels, such as MBS convexity (Hanson, 2014), and provide a more nuanced view of how monetary policy reshapes bond market allocations. Lastly, 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; Chaudhary 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 approach allows us to capture transmission dynamics that involve multiple market segments, such as the substitution between Treasuries and MBS.

2 Data

We construct a comprehensive dataset of portfolio holdings across five major types of bond investors: mutual funds, insurance companies, banks, primary dealers, and the Federal Reserve. Mutual fund holdings at the CUSIP level are from Morningstar. Insurance company holdings at the CUSIP level are NAIC filings. Bank holdings at the maturity bucket level come from FFIEC Call Reports. Primary dealer holdings at the maturity bucket level come from the New York Fed. Fed holdings under SOMA and SMCCF at the CUSIP level are from the New York Fed. Appendix A provides additional details on our holdings data.

We focus on three classes of bonds – Treasuries, corporate bonds (including agency direct obligations), and agency MBS – which together virtually span the entire U.S. taxable bond market. Data sources include CRSP, Mergent FISD, TRACE, and Refinitiv. Bond yields as well as bond characteristics such as credit rating and duration are carefully constructed to ensure consistency across instruments, with details provided in Appendix B. Table 1 provides summary statistics of bond portfolios.

Our final sample goes from 2003Q1 to 2022Q4. Figure 1 displays the holdings of the five investor types we focus on. A key takeaway is that these investors hold multiple classes of debt securities, motivating the use of a demand system that studies them jointly. The bonds for which we have detailed data account for the majority of their portfolios. Figure A1 shows the investor composition for Treasuries, corporate bonds, and agency MBS, confirming that the investors we focus on cover the majority of these markets. The remainder is grouped into an "other investors" category.

3 Stylized Facts on Portfolio Adjustments in Response to Monetary Policy

In this section, we present several new 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 not covered by our data (e.g. foreign investors) are labeled as the residual sector.[7] In addition to analyzing investor behavior, we also examine net issuances of Treasuries, MBS, and corporate bonds.

We run the following quarterly time series regression for each sector and separately for

[7] See Tabova and Warnock (2021) for an analysis of foreign investors and their investments in U.S. Treasuries.

Treasuries, MBS, and corporate bonds:

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

Δq denotes the year-over-year change in par amount held by the sector, scaled by the total amount outstanding of Treasuries, MBS and corporate bonds combined. Δr^{1Y} denotes the year-over-year change in the one-year Treasury rate, serving as a proxy for conventional monetary policy.[8] Δq^{FED} denotes year-over-year net purchases of Treasuries and MBS by the Fed, scaled by the total bond market. X denotes a set of control variables, such as GDP growth and inflation rates. Standard errors are adjusted for serial correlation with four lags (Newey and West, 1994). β_1 and β_2 represent changes in portfolio holdings associated with conventional and unconventional monetary policy, respectively.

To be clear, these coefficients present reduced-form correlations rather than causal effects. We will explore the economic mechanisms underlying these empirical patterns in the demand system in Section 4. Before doing so, however, it is helpful to understand the basic signs and magnitudes of these correlations. Results are plotted in Figures 2 and 3, with exact numbers shown in Table 2.

3.1 Changes in holding amounts

We first describe how holding amounts change following conventional monetary policy in Panel A of Figure 2. 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 their bond holdings by a total of 0.44% of the market over the same year, spanning Treasuries, MBS, and corporate bonds. This is consistent with the fact that bond mutual funds tend to experience large inflows of return-chasing capital when interest rates

[8] The results are robust if we use monetary policy shocks as an instrument.

decline (Brooks et al., 2018; Fang, 2023). Panel A of Figure 4 shows that, following a 100 bps rate cut, bond mutual funds experience inflows equal to about 2% of their AUM in the first quarter, increasing to 7% after four quarters.

Similar to mutual funds, Figure 2 shows that in response to a 100 bps rate drop, banks increase their holdings of Treasuries and MBS by a total of 0.39% of the market. The contribution from corporate bonds is negligible, as banks hold only small quantities of them. The increase in bond holding is driven by large inflows of checking and savings deposits when rates fall (Drechsler, Savov, and Schnabl, 2017). As shown in Panel A of Figure 4, banks experience significant inflows following a 100 bps rate cut, with about 3% of their AUM in one quarter, rising to 8% in four quarters. These flows are likely to come from short-term saving vehicles such as money market funds, whose yields are determined by the short-term policy rates (Xiao, 2020).

In contrast to mutual funds and banks, there are small *net* changes to the holdings of insurance companies. As shown in Figure 4, retail flows to insurers (i.e. sales of insurance policies) do not correlate with monetary policy, which depend more on long-term demographic and economic factors rather than short-term interest rate changes. The fact that they reduce their Treasury holdings suggests that they seem to act as liquidity providers for mutual funds and banks.

Mutual funds and banks together purchase Treasury bonds, MBS, and corporate bonds equal to 0.85% of total market size, respectively, in response to a 100 bps rate drop. This demand expansion is substantial, equivalent to 1.4% of annual GDP. Who, then, are the sellers that clear the market? Existing literature emphasizes the role of dealers as liquidity providers.[9] However, as shown in Figure 1, primary dealers hold less than 1% of the total bond market. During episodes when all investors trade in the same direction, it would be implausible for primary dealers to meet the entire demand. In fact, at an annual frequency, primary dealers

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

are typically on the same side as mutual funds and banks, expanding their bond holdings when rates fall, as shown in Figure 2.[10]

If primary dealers do not accommodate the majority of investor demand, who takes the other side? After all, the accounting identity that purchases must equal the sum of sales and issuance has to hold. It turns out that most of the demand is met through new issuances 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 0.90% of total market size. The magnitude is comparable to the total purchases by mutual funds and banks. Issuances by mortgage borrowers and corporations are more sensitive to interest rate changes than the Treasury Department, highlighting their elasticity to investor demand (Sammon and Shim, 2024).

3.2 Changes in portfolio characteristics

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

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

Δx denotes the year-over-year change in the weighted average of credit rating (AAA = 0, CCC = 6) or option-adjusted duration across all bonds in the portfolio. Δr^{1Y} denotes the year-over-year change in the one-year Treasury rate. Δq^{FED} denotes year-over-year net purchases by the Fed of Treasuries and MBS, scaled by the total market size.

Results on changes in credit rating are shown in Panel B of Figure 2. In response to a 100

[10] This does not rule out the possibility that primary dealers play a more important role at high frequency.

bps rate cut, the average credit rating of all corporate bonds outstanding in the market deteriorates by 0.016 of a letter grade. Relative to this market average, mutual funds' credit rating deteriorates more, by 0.031, 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 0.012, 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 2. The most salient result is that the option-adjusted duration of MBS declines substantially, by 0.27 years on average, 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 investors, as it impacts all existing MBS.

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 (corporate bonds) increases by 0.07 (0.14) 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.

Insurance companies are also aggressive in increasing the duration of their bond holdings. This is because, even though they have small exposure to MBS, insurers 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 0.09 (0.12) years, or 3 (2) 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 Portfolio adjustments to unconventional monetary policy

Portfolio responses to unconventional Fed policies — direct purchases Treasury bonds and MBS — are given by β_2 of Equation 1.[11] Results are shown in Figure 3. The patterns are very similar to those observed for conventional monetary policy. 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% in four quarters (Panel B of Figure 4). Given the inflows, bond mutual funds increase their purchases of Treasury bonds, MBS and corporate bonds by 0.20% in total. Banks also receive inflows of about 1% in a quarter and 2% in four quarters after the Fed purchases 1% of the bond market (Panel B of Figure 4). Facing the inflows, banks purchase Treasuries and MBS by 0.26% of total bond market. Mutual funds and banks together purchase another 0.5% of the market in response to 1% of Fed purchases, acting as a "helping hand" that amplifies the Fed's actions.

From whom do the Fed and other investors buy the bonds? Primary dealers only supply 0.05% of bonds outstanding in response to 1% of Fed purchases. 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 0.77%, MBS by 0.42%, and corporate bonds by 0.18% of total market outstanding.

[11] We do not analyze portfolio responses to the Fed's SMCCF purchases in 2020 as they are too small in quantity ($14 billion at peak) and have a very short history.

Finally, changes in portfolio characteristics following unconventional monetary policies are 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 banks and insurance companies.

4 Demand System Framework

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

1. When the Fed eases monetary policy by lowering short-term rates or purchasing safe assets, mutual funds experience retail inflows and proportionally scale up their bond holdings.

2. Insurance companies lengthen portfolio durations to hedge liabilities.

3. Banks engage in both activities to accommodate deposit inflows and counteract the shortening duration of mortgages.

4. Primary dealers play limited role in absorbing the monetary-policy-induced demand over a long horizon. The demand is absorbed by mostly bond issuance.

This section develops a demand system in the style of Koijen and Yogo (2019) to jointly analyze both prices and quantities in equilibrium. The objective is to address key questions that are difficult to quantify 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 bank does. Lastly, many bond investors buy and hold 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.

4.1 Intuition

To build intuition before introducing the full demand system, we consider a simplified supply-and-demand framework for a representative long-term bond, shown in Figure 5. The vertical axis plots the negative of risk premia (e.g., term and credit spreads), and the horizontal axis shows the quantity of bonds outstanding.

Panel A represents the scenario with frictionless financial markets and perfectly elastic asset demand, such as in the textbook New Keynesian model. In this case, a rate cut lowers the cost of capital, encouraging investment and increasing bond issuance. General equilibrium effects, such as higher aggregate demand, further increases issuance. However, risk premia remain unchanged, and monetary policy affects long-term yields only via expected short-rate movements, which is insufficient to explain their observed high sensitivity.

This motivates Panel B, where asset demand is downward-sloping. But inelastic demand alone cannot explain falling risk premia after a rate cut. If bond supply rises but investors have limited risk-bearing capacity, risk premia would increase (from point a to b), contradicting the data. The resolution is that monetary easing must also shift asset demand outward (b to c), with the demand increase outweighing the supply shift to reduce risk premia.

Panel C extends the logic over time. In the short run, supply is inelastic, so a rate cut lowers risk premia sharply (a to b). Over time, issuers respond by increasing supply, and greater elasticity tempers the effect on yields (b to c). A lower risk-free rate also contributes to higher issuance. This dynamic helps explain the reversal of yield responses at longer horizons, as documented by Hanson et al. (2021), without diminishing the central role of investor demand in driving initial yield movements.

4.2 Assets

Instead of individual bonds, we work with portfolios of bonds. In our baseline framework, bonds are sorted into 3 classes (Treasury, corporate, MBS), 7 rating groups (AAA, AA, A, BBB, BB, B, CCC or lower), 30 maturity buckets (1 year or less, ..., 30 years or longer), 11 coupon levels (0%, 1%, ..., 10% or higher), and callability (yes v.s. no).[12] 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 (Li and Lin, 2024; Chaudhary, Fu, and Li, 2022). Working with bond portfolios also greatly simplifies computation.[13]

Bond portfolios are indexed by $n = 1, ..., N$. Each bond portfolio has par amount outstanding $S_t(n)$, yield to maturity $y_t(n)$, and a vector of characteristics $\boldsymbol{x}_t(n)$ including credit rating, duration, coupon rate, and bid-ask spread. The construction of these variables is detailed in Appendix B.

Our focus is on the risk premium component of bond yields. To this end, we exclude the component of bond yield due to short-term risk-free rate and its expected path, which is exogenously controlled by the Fed and can be measured using professional forecasts (Nagel

[12]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.

[13]At a given point in time, there are approximately 300+ Treasury CUSIPs, 30,000+ corporate CUSIPs, and 500,000+ MBS CUSIPs outstanding.

and Xu, 2024). Details of how to measure the expected short rate component of bond yield at each time and for each tenor are described in Appendix C. The risk premium component $\tilde{y}$ is then simply measured as the residual $\tilde{y} = y - y_f$. Term spread is simply defined as $\tilde{y}$ for Treasury bonds. Credit spread or MBS spread is defined as yield spread over a duration-matched Treasury, as conventionally done. For simplicity, we will refer to the risk premium component as yield y for the remainder of the paper.

We treat cash and cash equivalents (including deposits, money market instruments, Treasury bills, and Treasury notes and bonds with less than one year to maturity) as the base bond ($n = 0$). The yield on cash is exogenously controlled by the Fed, so the its supply is perfectly elastic. Cash carries zero yield (over the expected short rate component), AAA rating, zero duration, 0% coupon, and 0% bid-ask spread.

Other bonds (e.g. foreign bonds) and other assets (e.g. equities) are outside our model. We will treat investors' allocation between U.S. bonds (including cash) 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 equities. We make the deliberate decision not to treat these outside assets as cash, which is conventionally done, because outside assets can have large returns due to monetary policy, and treating them as yield-less cash may severely bias the results.

4.3 Investors

Investors are indexed by $i = 1, ..., I$. We focus on three types of institutional bond investors for which we have detailed data on portfolio holdings: mutual funds, insurance companies, and banks. Some investors hold a small set of bonds, which can be problematic for estimation. To address this, we group individual investors into 79 mutual fund groups (by Morningstar Category and by active v.s. passive), 20 insurance company groups (by life v.s. 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 three investor types above and the total amount outstanding for each bond portfolio.

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

$$w_{i,t}(n) = \frac{\exp\{\alpha_{i,t} y_t(n) + \boldsymbol{\beta}'_{i,t} \boldsymbol{x}_t(n) + \epsilon_{i,t}(n)\}}{\sum_m \exp\{\alpha_{i,t} y_t(m) + \boldsymbol{\beta}'_{i,t} \boldsymbol{x}_t(m) + \epsilon_{i,t}(m)\}} \tag{3}$$

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:

$$\frac{\partial w(m)/w(m)}{\partial y(n)} = \begin{cases} \alpha(1 - w(n)) & m = n \\ -\alpha w(n) & m \neq n \end{cases} \tag{4}$$

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 weight becomes an integral over the distribution of $\boldsymbol{\beta}$:

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

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:

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

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). To illustrate, consider an exogenous reduction in the duration of MBS (e.g. due to an unexpected rate cut), prompting banks to seek substitutes. Under the standard logit demand framework, a bank would reallocate funds proportionally across its portfolio. However, in reality, banks may prefer to reallocate more heavily into long-term Treasuries instead of corporate bonds with low credit ratings. The random demand coefficient model allows for this more flexible portfolio adjustment, enabling investors to allocate funds disproportionately toward assets with similar characteristics.

4.4 Equilibrium

In equilibrium, market clears, meaning that the demand by investors equals the market supply for each bond portfolio. The market clearing condition is:

$$S_t(n)P_t(n) = \sum_{i=1}^{I} A_{i,t} w_{i,t}(n) \tag{7}$$

where the left-hand side represents the market value of bond n outstanding, and the right-hand side represents total demand of bond n across all investors. Market clearing applies to all bonds except for cash ($n = 0$), where the supply is controlled by the Fed and perfectly elastic.

Similar to Koijen, Richmond, and Yogo (2023), we endogenize investor AUM with respect to asset prices. Bond AUM obeys the following law of motion:

$$A_{i,t} = A_{i,t-1} R_{i,t} + T_{i,t} \tag{8}$$

The first component captures changes in bond AUM due to returns:

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

where bond return includes both coupon payments and price changes. Note that we use portfolio weights as of the current equilibrium because we want to endogenize the effects of current portfolio weights on prices.

The second component T captures changes in bond AUM due to net purchases and is measured by changes in par values Q and prices P:

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

We further separate out net purchases that are driven by flows $T^F_{i,t} = A_{i,t-1}F^{\%}_{i,t}$ and other net purchases $T^O_{i,t} := T_{i,t} - T^F_{i,t}$, where $F^{\%}_{i,t}$ denotes flows as the fraction of the investor's total AUM that includes both bonds and non-bonds $F^{\%}_{i,t} = F^{\$}_{i,t}/A^{total}_{i,t-1}$. In other words, T^F captures changes in bond AUM if the investor proportionally scale up or down its bond portfolio in response to flows. T^O captures portfolio shift to bonds versus other assets such as equities.

4.5 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 portfolio's own characteristics and those of its peers, where a peer is defined as bond portfolios whose rating, duration, coupon are within one standard deviation of the target bond portfolio's.[14]

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, investor i's idiosyncratic flows (scaled by lagged AUM) at time t are given by residuals from a principal component regression:

$$InvestorFlow_{i,t} = a + bPC_t + Invest\tilde{o}rFlow_{i,t}$$

where PC_t denotes the first principal component of flows across all investors. These investor-

[14]For example, for 5-year, 5% Treasury bonds, peer bonds are those with maturities between 2 and 8 years and coupons between 4% and 6%, excluding bonds with exactly 5-year maturity and 5% coupons.

level idiosyncratic flows are then aggregated for each bond portfolio, excluding flows to the investor of interest:

$$FIT_{-i,t}(n) = \frac{\sum_{j \neq i} AmountHeld_{j,t-1}(n) Inves\tilde{tor}Flow_{j,t}}{AmountOutstanding_{t-1}(n)} \tag{9}$$

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 regression for each investor at each time:

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

Table A1 shows that 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 $\boldsymbol{z}(n)$.

4.6 Estimation

We estimate demand coefficients — which include the sensitivity to yield $\alpha_{i,t}$ and the sensitivity and its dispersion to characteristics $(\boldsymbol{\mu}_{i,t}, \Sigma_{i,t})$ — for each investor at each time. To simplify computation, we restrict Σ to be a diagonal matrix and only allow random coefficients on rating and duration. We include not only the investor's current holdings but also their holdings in the quarter before and the quarter after, as time series variation can be important for identification.[15] We closely follow the estimation procedure in Berry et al.

[15] See the last two paragraphs of Section 3.2 of Nevo (2000).

(1995) and describe the details in Appendix D.

Table 3 and Figure A3 show our estimated demand coefficients. The mean coefficients $\boldsymbol{\mu}$ exhibit expected regularities.[16] 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.

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 due to the valuation effect.[17] To better

[16] 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% (e.g., from 1% to 1.1-1.3%). 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 6.

[17] 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.

understand their economic magnitude, we calculate price elasticities based on Equation 6[18]:

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

The equation shows that price elasticity varies across pairs of bonds, which is a key feature of our framework. 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 and duration buckets and calculate the average cross-elasticities.

Table 4 shows estimated own-price and cross-price elasticities, averaged across bonds and bond pairs with the given rating letters or duration buckets and separately for 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. Our estimated price elasticity is in the middle of the spectrum estimated by Chaudhary et al. (2022), who finds that the average price elasticity (the reciprocal of price multiplier) is 0.8 at the level of coarse rating $\times$ short/medium/long-term maturity portfolios and 3 at the level of detailed rating *times* quarters to maturity portfolios.

The off-diagonal numbers show cross-price elasticities according to Equation 10, with $m \neq n$.

[18]Similar to Bretscher et al. (2021), portfolio weight $w(m)$ and par amount 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:

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

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. 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, to the best of our knowledge, we are the first to achieve this in a structural model, 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 A2 shows that, consistent with the prediction in Equation 4, fixed coefficients produce rigid homogeneous cross-substitution, as the cross-elasticity numbers are essentially invariant for each column.[19]

4.7 Decomposition

The market clearing condition (Equation 7) presents the equilibrium yields $\boldsymbol{y}$ as an implicit function of the demand-side factors, including investor AUM $\boldsymbol{A} = \{A_i\}$, investor demand coefficients $\boldsymbol{\Theta} = \{(\alpha_i, \boldsymbol{\mu}_i, \Sigma_i)\}$, investor latent demand $\boldsymbol{E} = \{\epsilon_i(n)\}$, and the supply-side factors, including bond characteristics $\boldsymbol{X} = \{\boldsymbol{x}(n)\}$, and bond amount outstanding $\boldsymbol{S} = \{S(n)\}$:

$$\boldsymbol{y} = \boldsymbol{g}(\boldsymbol{A}, \boldsymbol{\Theta}, \boldsymbol{E}, \boldsymbol{X}, \boldsymbol{S}). \tag{11}$$

We use the following procedures to derive counterfactual market-clearing bond yields numerically. First, we take an initial guess at yields $\boldsymbol{y}$ (e.g., the actual yields from the last

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

period). Then, given bond characteristics $\boldsymbol{X}$, investor demand coefficients $\boldsymbol{\Theta}$, and latent demand $\boldsymbol{E}$, we obtain portfolio weights $\{w_i(n)\}$. Given bond investor AUM $\boldsymbol{A}$ and portfolio weights $\{w_i(n)\}$, investors' total dollar demand for bond n is $\sum A_i w_i(n)$, the right-hand side of Equation 7. 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 perform an empirical decomposition of bond yield changes into different channels, following 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:

$$\Delta \boldsymbol{y}_t(c) := \boldsymbol{g}(c_t, c^-_{t-1}) - \boldsymbol{g}(c_{t-1}, c^-_{t-1}) \tag{12}$$

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 $\boldsymbol{S}$, we separately feed the model $\boldsymbol{S}_{t-1}$ and $\boldsymbol{S}_t$ while holding all other parameters ($\boldsymbol{A}$, $\boldsymbol{\Theta}$, $\boldsymbol{E}$, $\boldsymbol{X}$) fixed at their values as of $t-1$, and we calculate the market-clearing bond yields $\boldsymbol{g}(\boldsymbol{A}_{t-1}, \boldsymbol{\Theta}_{t-1}, \boldsymbol{E}_{t-1}, \boldsymbol{X}_{t-1}, \boldsymbol{S}_{t-1})$ and $\boldsymbol{g}(\boldsymbol{A}_{t-1}, \boldsymbol{\Theta}_{t-1}, \boldsymbol{E}_{t-1}, \boldsymbol{X}_{t-1}, \boldsymbol{S}_t)$ from Equation 11. The differences $\Delta \boldsymbol{y}_t(\boldsymbol{S})$ are attributed to changes in amount outstanding $\boldsymbol{S}$.

Changes in bond AUM come from bond returns or changes in par amounts. Bond returns are driven by changes in expected short rates y_f — which are exogenously controlled by the Fed — or changes in risk premium $\tilde{y}$ — which are endogenous and characterized in Equation 8. For the counterfactual analyses, we focus on changes in par amounts and further separate out flow-induced net purchases T^F and other net purchases T^O, as described in Section 4.4. 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 reconstitution 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 conventional and unconventional monetary policy. The contribution of channel c to yield sensitivity is measured through the following regression:

$$\Delta y_t(c) = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \gamma X_t + \epsilon_t \tag{13}$$

where $\Delta y_t(c)$ denotes year-over-year changes in aggregate yields (e.g. average yields across Treasury bonds with 10-year duration) attributable to channel c according to Equation 12, Δr_t^{1Y} year-over-year changes in the one-year Treasury rate, Δq_t^{FED} the Fed's net purchases of Treasuries and MBS (as percentage of total bond market), and X_t macroeconomic variables including contemporaneous GDP growth and inflation rate. β_1 and β_2 tell us, respectively, the contribution of channel c to sensitivity to conventional monetary policy and unconventional monetary policy. Standard errors are adjusted for serial correlation with four lags (Newey and West, 1994).

5.1 Term spread

Figure 6 presents our decomposition of the monetary sensitivity of the 10-year term spread, which is the 10-year Treasury yield minus the expected short rate component, as defined in Section 4.2. Panel A shows the contributions by each channel. The black bar on the right displays the observed sensitivity of the 10-year term spread to monetary policy. Consistent with existing literature, a 100 bps increase in the one-year Treasury rate is associated with a 41 bps increase in the 10-year Treasury term spread at the quarterly frequency and a 21 bps increase at the annual frequency. There are two puzzles to be addressed: how does monetary policy affect term premia and generate the excess sensitivity of long-term yields, and why does it diminish at low frequency.

The other colored bars in Panel A represent estimated contributions from specific channels, where red (blue) indicates a positive (negative) contribution. These effects accumulate from left to right; the top of a red bar or the bottom of a blue bar reflects the cumulative contribution up to that point. Figure A5 provides a more granular breakdown by investors and by characteristics.

Investor flows are a leading factor that amplifies the term spread sensitivity to monetary policy by 24 bps. Allocation between bonds and other assets slightly dampens sensitivity by 4 bps. Demand for characteristics amplifies the sensitivity by 17 bps, primarily through duration demand (11 bps), with an additional effect from coupon rate demand (5 bps). Changes in characteristics amplify sensitivity by 11 bps, largely due to the duration effect of callable bonds (14 bps). These demand-side channels together amplify term spread sensitivity by 49 bps.

Panel B provides a further decomposition of demand-side channels by investor type — bond funds, balanced funds, life insurers, P&C insurers, and banks. Each demand channel is represented by a colored bar, stacked vertically within each investor type. Channels that amplify yield sensitivity appear above the horizontal axis; those that dampen it appear below. Investor flows are primarily driven by bond mutual funds (12 bps) and banks (9 bps). During monetary easing (tightening), these investors receive large inflows (outflows), creating significant buying (selling) pressure (Drechsler et al., 2017; Fang, 2023; Darmouni et al., 2024). Balanced funds are the main contributors to the dampening effect from allocation, as their flexible mandates lead them to rebalance toward (away from) equities when bond prices rise (fall) during monetary easing (tightening) (Lu and Wu, 2023). The amplification from demand for duration largely comes from life insurance companies. As monetary policy eases (tightens), the duration of liabilities lengthens (shortens), prompting these investors to adjust the duration of their bond holdings accordingly (Domanski et al., 2017; Ozdagli and Wang, 2019). All investors, in particular banks, tilt toward long-term bonds when the duration on MBS shortens.

On the supply side, net issuances of bonds substantially dampen sensitivity, reducing it by

36 bps. During monetary easing (tightening), bond issuance increases (decreases), raising (lowering) bond yields and offsetting demand-side pressures. Panel C further disaggregates the effects by issuer. While one might associate the Treasury term spread solely with Treasury issuance, the decomposition reveals that its sensitivity is driven more by corporate and household issuance than by the Treasury itself. Consistent with our stylized facts in Section 3, during monetary easing (tightening), corporations and households issue (redeem) more bonds, resulting in more (less) supply of long-term bonds, which pushes down (up) the term spread. This highlights the interconnectedness of different bond classes and the importance of jointly studying them in the same framework.

5.1.1 Quarterly v.s. annual frequency

In addition to the year-over-year frequency, we show our yield sensitivity decomposition at the quarter-over-quarter frequency in Panel A of Figure 7. Issuance plays a much smaller role at the quarterly frequency. This limited short-run dampening effect helps explain why long-term yields exhibit greater sensitivity in the short run. Taken together, our results provide a coherent explanation for both of the puzzles we highlighted at the beginning of the section: following a rate cut, demand for long-term bonds rises, but the supply response is delayed, leading to a sharp decline in long-term yields in the short run. As issuance gradually increases, the yield movement partially reverses.

This finding has important policy implications. Without accounting for issuance, one might conclude that the long-run reversal implies that the large impact of monetary policy on long-term yields is merely a liquidity effect, gradually eroded by arbitrage over time. For example, Hanson et al. (2021) write, "Our findings suggest that the recruitment channel may not be as strong as Stein (2013) speculates since a portion of the resulting shifts in term premia are transitory..." A key implication of our result is that the reversal actually reflects a substantial impact of monetary policy on bond issuance, which aligns with the objectives of policymakers.

5.1.2 Early v.s. late period

The financial system has undergone significant structural changes — for instance, the bond mutual fund sector has expanded rapidly in recent decades. It is natural to expect that the strength of these transmission channels can vary over time, contingent upon 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.

Panel B of Figure 7 shows the results. The amplification effects from bond mutual funds have increased significantly in the latter half of our sample, from 8 to 19 bps. This reflects the secular rise of bond mutual funds relative to insurance companies and banks (Ma et al., 2025).[20] Consequently, changes in the short-term rates are associated with larger quantities of flow-induced bond demand relative to bonds outstanding.

The dampening effect of net issuances has almost doubled, from -25 to -43 bps. Bond issuance 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 25 bps in the first half of our sample to 19 bps in the second half of our sample. This result provides 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

[20] 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.

issuance sensitivity, a sign of strengthened transmission to the real sector.

5.2 Credit spread

Figure 8 shows our decomposition of monetary sensitivity for the BBB credit spread, which is the average difference between the yields of BBB-rated corporate bonds and the yields of duration-matched Treasury bonds. Panel A presents the observed sensitivity (black bar on the right) as well as contributions from different channels (red for positive, blue for negative), accumulated from left to right.

Investor flows amplify the sensitivity of credit spreads by 3.7 bps, as shown by the first red bar in Panel A. Demand for characteristics also contributes meaningfully, increasing sensitivity by 2.7 bps. In contrast, issuance significantly dampens sensitivity. The issuance effect is large enough that the cumulative contribution of all channels results in a negative overall sensitivity — meaning that a rate cut leads to a widening of credit spreads, suggesting that the supply curve shifts more than the demand curve.

Panel B of Figure 8 breaks down the demand-side channels by investor type. It shows that the amplification from investor flows is primarily driven by active mutual funds. This is because active mutual funds naturally tilt towards corporate bonds (Barth, Kahn, Monin, and Sokolinskiy, 2024) relative to Treasuries, so their flows have larger effects on corporate yields than on Treasury yields.

Demand for characteristics, particularly for credit ratings, exhibits heterogeneity across investor types. During monetary easing, life insurers reduce credit risk exposure due to tighter regulatory constraints (Li, 2024), dampening sensitivity. In contrast, mutual funds tend to shift toward lower-rated bonds to "reaching for yield" (Choi and Kronlund, 2018), which compresses credit spreads and amplifies their sensitivity to monetary policy. Orthogonal to credit rating, investors appear to tilt towards high-coupon bonds to "reach for income" (Daniel, Garlappi, and Xiao, 2021).

Panel C of Figure 8 further decomposes the issuance channel by bond classes. It reveals opposing effects from corporate and government bond supply. During monetary easing (tightening), corporations issue more (fewer) bonds, which raises (lowers) credit spreads and reduces overall sensitivity. In contrast, governments and government-sponsored mortgage borrowers—who bear minimal credit risk—also increase (decrease) issuance, widening the gap between risk-free and corporate yields. This highlights the interconnectedness of different classes of bonds and the importance of studying them jointly in equilibrium.

5.3 MBS spread

Figure 9 shows our decomposition of monetary sensitivity for the MBS spread, which is the difference between the yields of MBS and the yields of duration-matched Treasury bonds. Panel A presents the observed sensitivity (black bar on the right) as well as the estimated contributions from different channels (red for positive, blue for negative), accumulated from left to right. The observed sensitivity is negative. When the Fed raises monetary policy rates, the MBS spread tends to narrow by 6.8 bps.

Investor flows amplify the sensitivity of the MBS spread by 5.9 bps. Panel B shows that the flow effect primarily comes from banks and active mutual funds. This is because banks naturally tilt their bond portfolios towards MBS relative to Treasury and corporate bonds, so monetary-easing-induced inflows would translate to higher relative demand for MBS than for other bonds, pushing down the MBS spread. Similarly, active mutual funds naturally tilt more towards MBS and corporate bonds relative to Treasuries (Barth et al., 2024), so monetary-easing-induced inflows to these investors would translate to higher demand for MBS compared to other bonds, which decreases the MBS spread.

Changes in duration also amplify MBS sensitivity by 1.1 bps. Panel B shows that there are opposing effects from insurance companies versus mutual funds and banks. During monetary easing, MBS duration shortens. This translates to lower demand from life insurers, who have a preference for long-duration bonds. In contrast, mutual funds and banks, on average, prefer short-duration over long-duration bonds, so their demand for MBS increases as MBS duration shortens.

Issuances and redemptions of bonds significantly dampen the monetary sensitivity of the MBS spread by 9.1 bps. When interest rates decline during monetary easing, households borrow more mortgages, which increases the amount of MBS outstanding and pushes up the MBS spread in order for investors to absorb the additional supply. Panel C further breaks down this effect by issuers and reveals that issuances by the Treasury Department and corporations have the opposite effect. This is because other bonds are imperfect substitutes for MBS, so increases in their amounts outstanding have larger effects on their own yields than on MBS yields. Therefore, the net effect on the MBS spread is amplification.

5.4 Bond issuances

This section quantifies the importance of "helping hand" channels — those driven by bond investors — in explaining bond issuance responses to monetary policy, compared to traditional channels such as movements in the risk-free rate and general equilibrium effects. As illustrated in Panel B of Figure 5, shifts in the demand curve capture the "helping hand" channel, while shifts in the supply curve reflect the effects of the risk-free rate changes and general equilibrium forces.

We begin by estimating the yield elasticity of aggregate net issuances through the following quarterly time series regression, conducted separately for Treasury bonds, corporate bonds, and MBS:

$$\Delta s_t = \kappa \widehat{\Delta y}_t + \zeta X_t + \nu_t.$$

Δs_t denotes aggregate year-over-year net issuances of Treasury bonds, corporate bonds, or MBS outstanding (scaled by aggregate outstanding). $\widehat{\Delta y_t}$ denotes instrumented year-over-year changes in aggregate Treasury term spread (over expected short rates), aggregate corporate spread (over duration-matched Treasuries), or aggregate MBS spread (over duration-matched Treasuries), where the instrument is flow-induced trading from Equation 9 but averaged across all bonds weighted by the amount outstanding (Gabaix and Koijen, 2021). X_t includes aggregate bond characteristics such as credit rating, duration, coupon rate, and bid-ask spread, as well as macroeconomic variables such as GDP growth and CPI inflation.

The estimated elasticities, shown in Table A3, indicate that issuances are highly sensitive to yield changes, especially for corporate bonds and MBS (e.g. Greenwood, Hanson, and Stein, 2010; Ma, 2019). Based on our decomposition of the monetary sensitivity of bond yield in the previous section, we can use our estimated issuance elasticity to derive a back-of-envelop decomposition of the impact of monetary policy on bond issuances. Recall that a 100 bps decline in the one-year Treasury rate leads to a 21 bps drop in the 10-year yield via changes in current and expected short rates. Figure 6 and Figure 8 show there are additional 48 bps decline in term spread and 7 bps decline in credit spread attributable to the "helping hand" channel.

Figure 10 shows our decomposition of corporate issuance sensitivity to 100 bps drop in one-year Treasury rate. The 21 bps yield decline due to changes in short-rate expectations increases issuance by $0.21 \times 1.667 = 0.35\%$. The 48 bps from term premia increases issuance by $0.48 \times 1.667 = 0.80\%$. The 7 bps from credit spreads adds $0.07 \times 1.667 = 0.12\%$. The sum of these effects is 1.27%, which accounts for nearly all of the observed 1.35% sensitivity in issuance (black bar in Figure 10). The small residual of 0.09% reflects the contribution of general equilibrium effects and other unobserved channels.

Two key takeaways emerge. First, the "helping hand" channel is approximately three times as large as the effect of the risk-free rate. This result does not depend on specific supply or demand elasticity estimates — it follows directly from the decomposition of the yield response to monetary policy into risk-free and risk premia components. Second, although our framework cannot directly quantify general equilibrium effects, the residual suggests there is limited scope for them to play a major role.

5.5 Dissecting unconventional monetary policies

This sub-section focuses on β_2 from Equation 13, i.e. yield sensitivity to the Fed's purchases of Treasuries and MBS through quantitative easing (QE).[21] Figure 11 shows the results. The black bar on the right shows observed yield response to Fed purchases equaling 1% of total bond market, which on average *positive* 6.8 bps. While QE is known to have large *negative* yield impacts on announcement days, the announcement effects tend to attenuates and reverse over time (D'Amico and King, 2013).

The other bars show contributions from different channels, where red bars indicate expansionary effects (yields go down) and blue bars contractionary effects (yields go up). The first bar shows direct effects from Fed purchases. When the Fed purchases Treasury bonds and MBS, the amount of Treasury bonds and MBS outstanding decreases, and their equilibrium yields must fall in order for investors to willingly hold less, so that the market clears. Quantitatively, 1% Fed purchases decrease term spread by 12 bps and MBS spread by 4 bps. Because corporate bonds are imperfect substitute, their yields decline less, which means that

[21] There are four QE episodes. QE1: from November 2008 to March 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.

their spreads relative to Treasuries increase, by 6 bps.

One notable result is that other investor channels — including investor flows, demand for duration and response to changes in duration — amplify the decline in term spread by another 18 bps, credit spread by another 9 bps, and MBS spread by another 4 bps. In other words, the direct effect from changes in the amount outstanding due to Fed purchases is only about half of the total effects resulting from changes in investor demand. The underlying mechanisms of these channels largely mirror those for conventional monetary policy. For example, during QE, mutual funds and banks experience large inflows of retail capital, which they translate to purchases of bonds that are tilted towards MBS and corporate bonds.

Issuances once again play an important role in absorbing the demand from the Fed and other investors. There is large upward dampening effect on term spread from issuances. As discussed in Section 3, there are large issuances of bonds concurrent with QE, which increase total bond amount outstanding and increase market-clearing yields. Issuances during QE decrease credit spread and have small upward effect on MBS spread. To understand this, recall from Section 3 that Treasury issuances are much larger than MBS and corporate issuances during QE. As a result, the upward yield impact is much larger for Treasury bonds than for corporate bonds, resulting in larger spreads between the two.

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 retail 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 amplifying demand is largely met by new issuance from the Treasury, mortgage borrowers, and corporations, while primary dealers play a more limited role. The demand and supply responses happen at different speeds, which explains the twin puzzles of the excess sensitivity of long-term yields and the long-run reversal. We argue that the long-run reversal does not imply the effect is merely transitory or unimportant. Rather, it reflects an active supply-side response: borrowers take advantage of lower yields by issuing more debt, which gradually offsets initial price pressure. Far from diminishing the macroeconomic impact of monetary policy, this response is a key part of its transmission — one that aligns with the objectives of policymakers.

To quantify these effects, we estimate a random-coefficient asset demand system using the full panel of portfolio holdings. We find that flows to mutual funds and banks, preferences for credit ratings and duration, and changes in callable bond duration all significantly contribute to the yield response. These effects vary across the term structure and credit spectrum, depending on time-varying factors such as investor composition and elasticity. Overall, the "helping hand" effect of monetary policy is three times as important as changes in risk-free rates in driving bond issuance.

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 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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Figures

Figure 1: **Investor Holdings of Debt Securities.** The figures show the holdings of the investors for which we have granular portfolio data: mutual funds (including ETFs), insurance companies (life and P&C), banks, primary dealers, and the Federal Reserve. The figures focus on holdings of debt securities — Treasury notes and bonds, corporate bonds (including agency direct obligations), agency MBS, cash and cash equivalents, municipal bonds, and other debt securities such as foreign bonds — and exclude holdings of equity-linked securities (e.g. convertible bonds), loans, and mortgages.

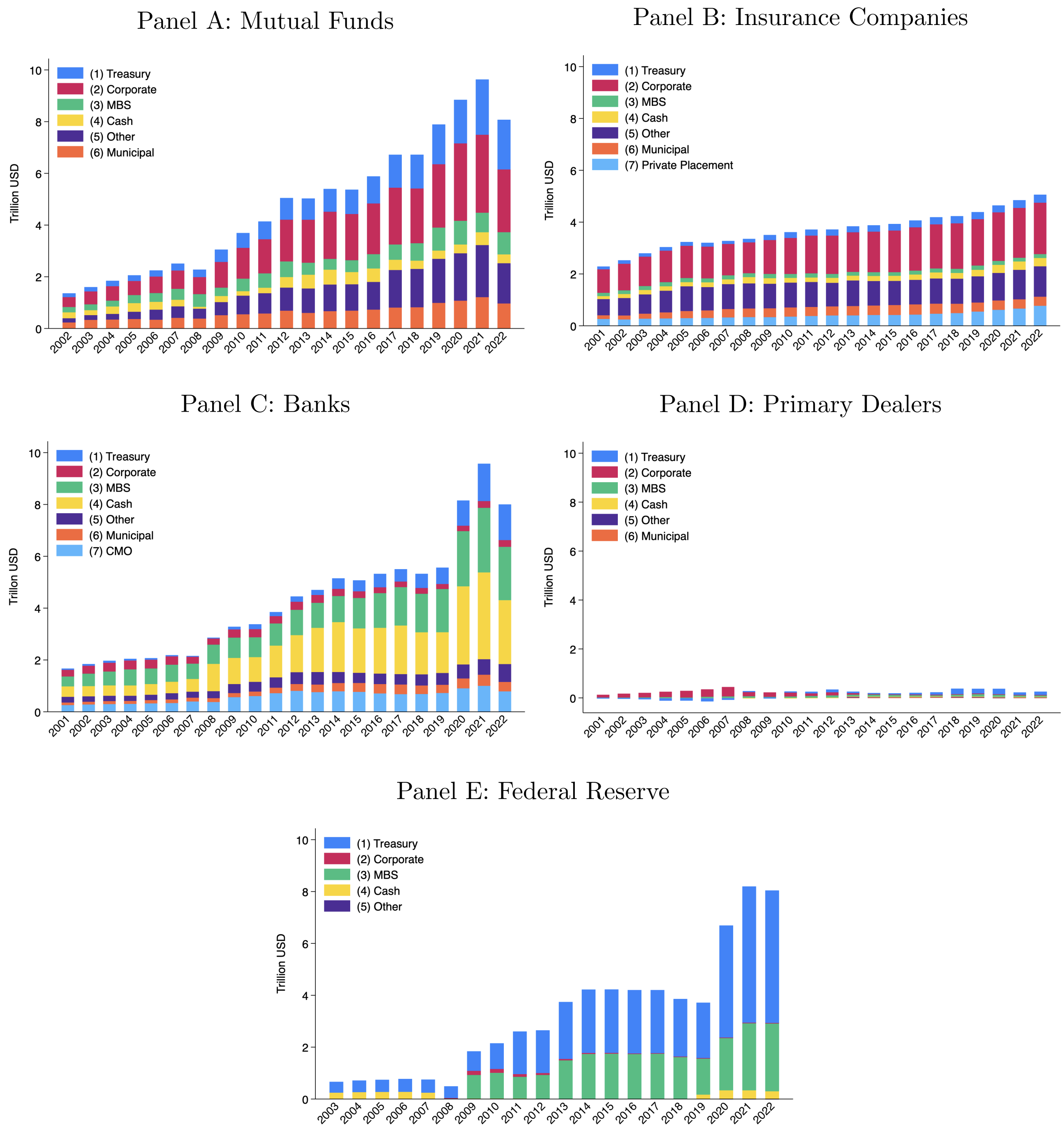
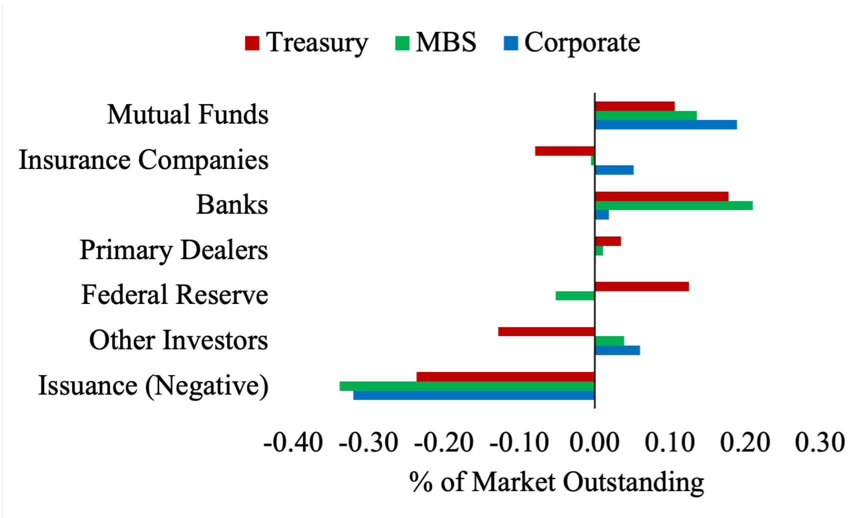
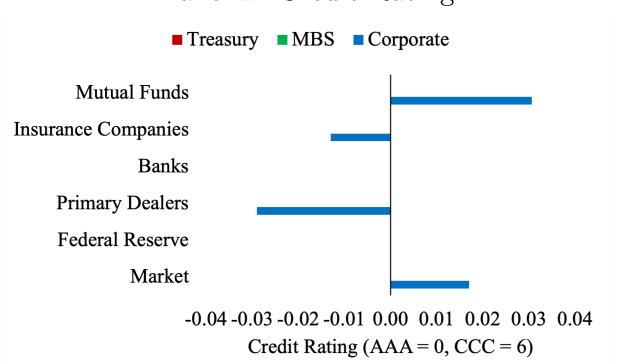


Figure 2: **Portfolio Changes to 100 bps Drop in One-Year Treasury Rate.** These figures report $-\beta_1$ from regression (1): $\Delta q_t = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \gamma X_t + \epsilon_t$, where Δq denotes year-over-year change in par amount held (as percentage of total bond market), change in average credit rating (AAA = 0, CCC = 6), or change in average duration (year), Δr^{1Y} denotes change in one-year Treasury rate (%), q^{FED} denotes net purchases by the Fed (as percentage of total bond market), and X includes GDP growth and CPI inflation. The regression is run separately for each investor group i and separately for Treasury bonds, corporate bonds and MBS.

Panel A: Amount



Panel B: Credit Rating



Panel C: Duration

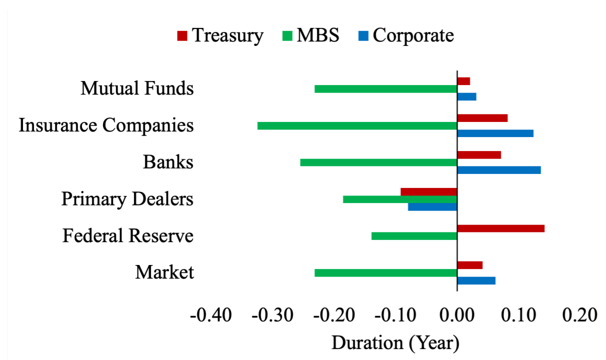
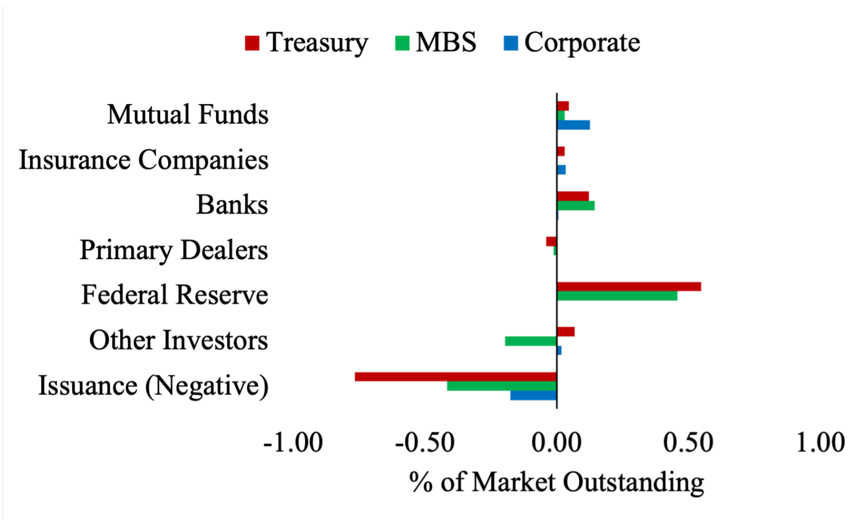
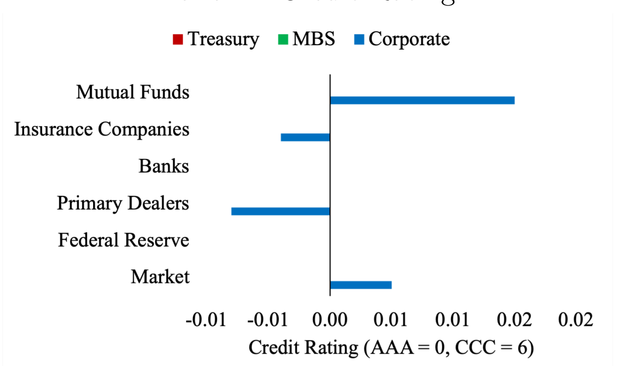


Figure 3: **Portfolio Changes to 1% Net Purchases by the Federal Reserve.** These figures report β_2 from regression (1): $\Delta q_t = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \gamma X_t + \epsilon_t$, where Δq denotes year-over-year change in par amount held (as percentage of total bond market), change in average credit rating (AAA = 0, CCC = 6), or change in average duration (year), Δr^{1Y} denotes change in one-year Treasury rate (%), q^{FED} denotes net purchases by the Fed (as percentage of total bond market), and X includes GDP growth and CPI inflation. The regression is run separately for each investor group and for separately for Treasury bonds, corporate bonds and MBS.

Panel A: Amount



Panel B: Credit Rating



Panel C: Duration

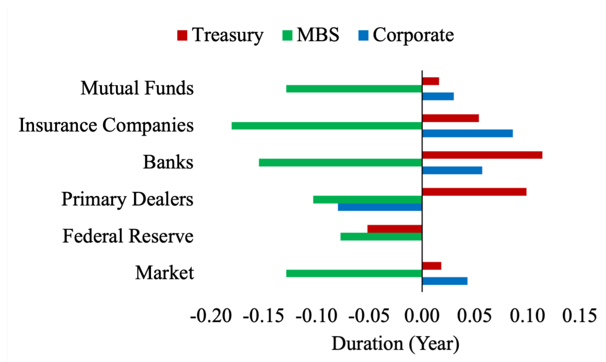
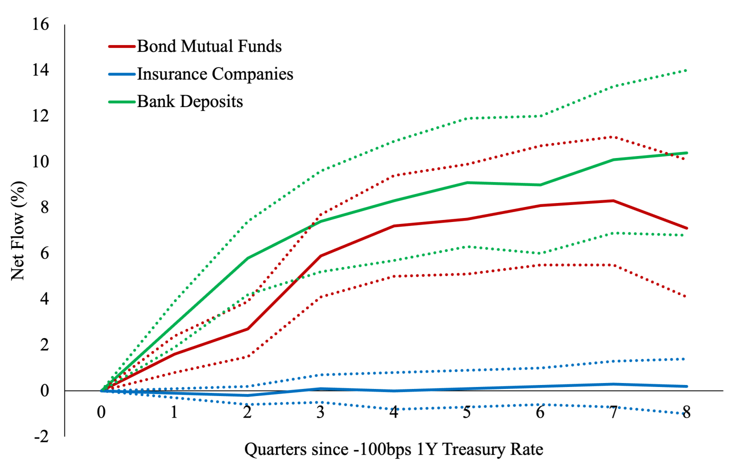


Figure 4: **Investor Flow Response to Monetary Policy.** The figures show impulse responses of net flows of bond mutual funds, insurance companies, and bank deposits to monetary policy, estimated as β_h from the following local projection regression: $Flow_{t,t+h} = \alpha_h + \beta_{1,h}\Delta r_{t,t+1} + \beta_{2,h}\Delta q^{FED}_{t,t+1} + \gamma X_{t,t+1} + \epsilon_{t,t+h}$. Panel A shows $-\beta_{1,h}$, i.e. net flow responses to a -100 bps drop in the one-year Treasury rate. Panel B shows $\beta_{2,h}$, i.e. net flow responses to the Fed's net purchases equaling 1% of total bond market.

Panel A: Conventional Monetary Policy



Panel B: Unconventional Monetary Policy

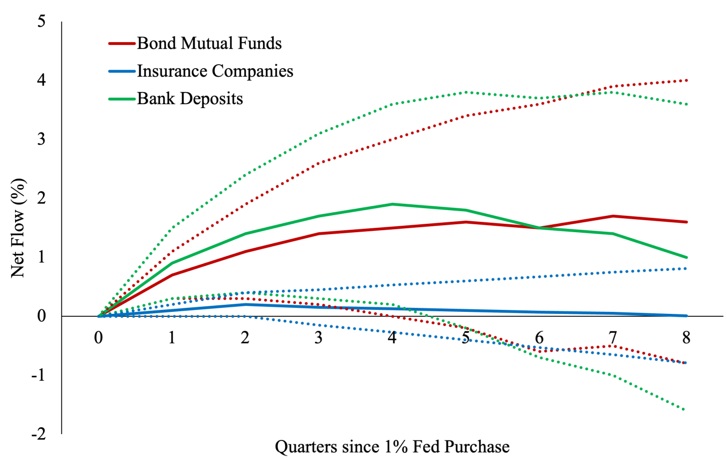
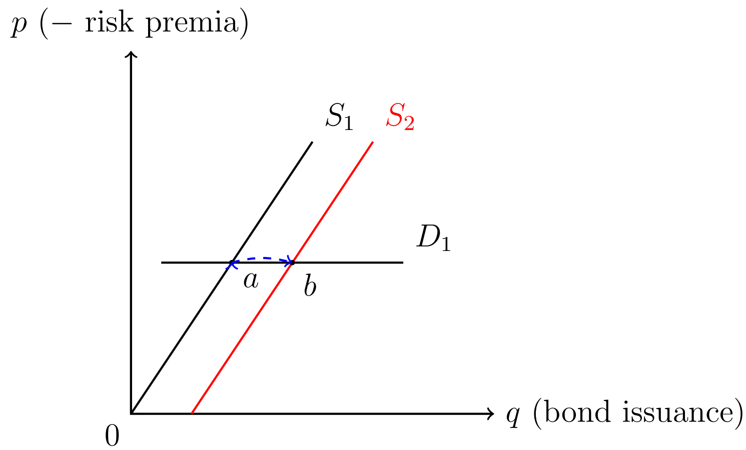
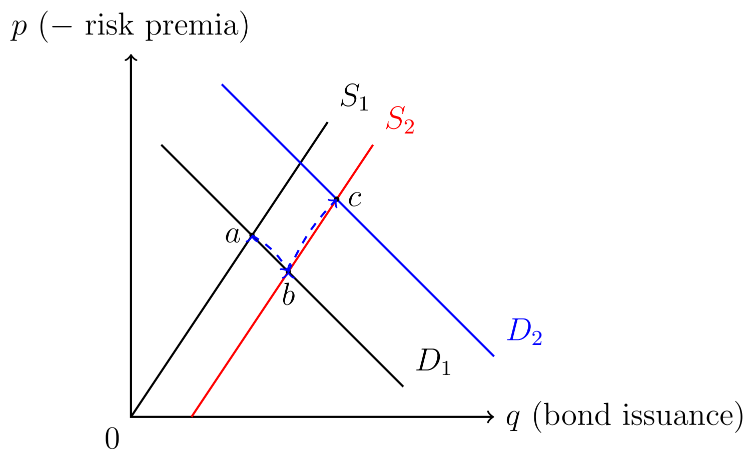


Figure 5: **Illustration of Supply and Demand of Bonds Following a Rate Cut.** The figures show supply and demand curves of long-term bonds following a rate cut. The vertical axis is negative risk premia. The horizontal axis is bond issuance.

Panel A: Constant Risk Premia



Panel B: Realist Asset Demand



Panel C: Short-run v.s. Long-run

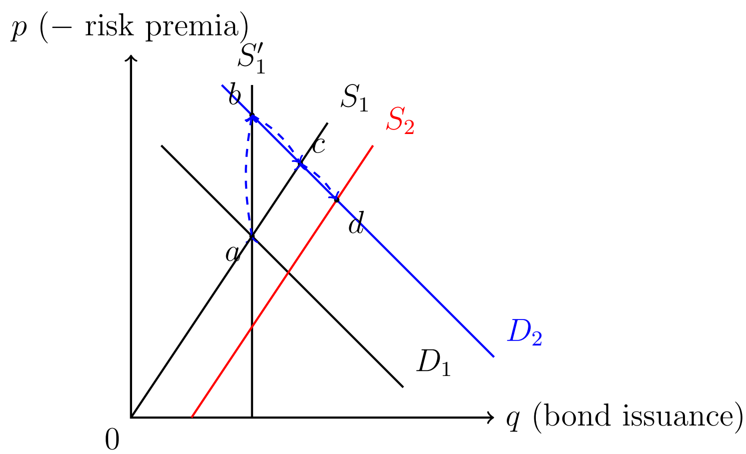
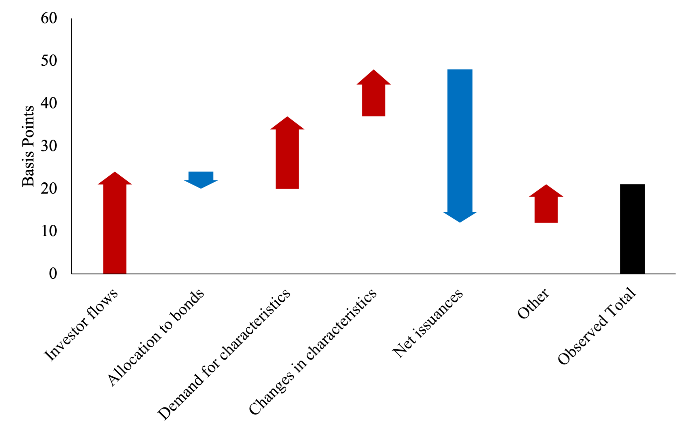
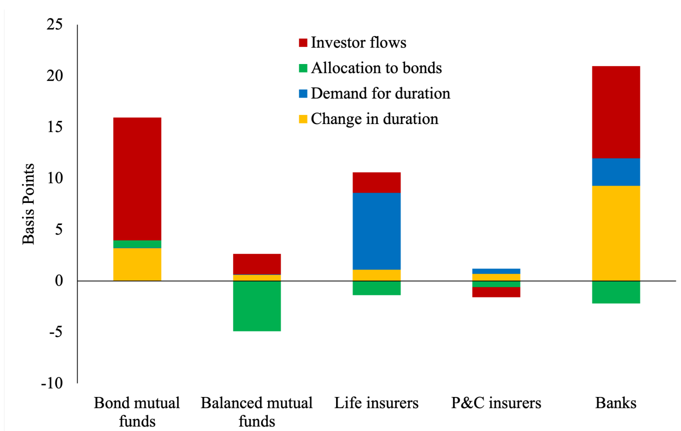


Figure 6: **Decomposition of 10-Year Treasury Term Spread Sensitivity to Monetary Policy.** These figures show contributions from different channels to the monetary sensitivity of 10-year Treasury term spread (over expected short rates). This is estimated as β_1 from regression (13): $\Delta y_t(c) = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \gamma X_t + \epsilon_t$ where $\Delta y(c)$ denotes changes in 10-year term spreads attributable to a specific channel c to term spread according to Equation 12, Δr^{1Y} the change in one-year Treasury rate, Δq^{FED} denotes net purchases by the Fed (relative to total market outstanding), and X includes GDP growth and CPI inflation.

Panel A: By Channel



Panel B: By Investor



Panel C: By Issuer

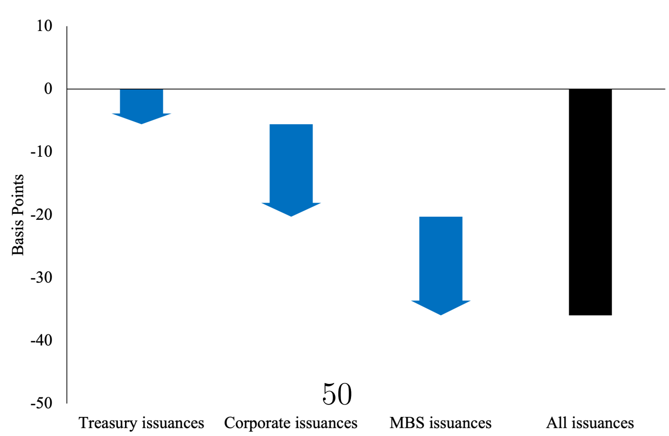
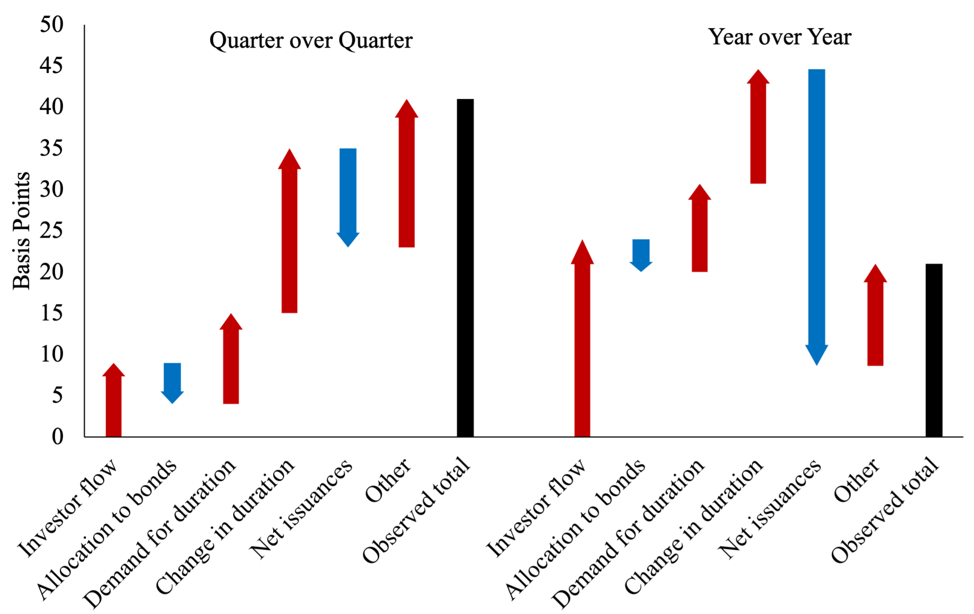


Figure 7: **Decomposition of Term Spread Sensitivity to Monetary Policy: Quarterly v.s. Annual and Early v.s. Late.** These figures show contributions from top channels to the monetary sensitivity of 10-year term spread, estimated as β_1 from regression (13). Panel A compares contributions at quarterly frequency v.s. annual frequency. Panel B compares contributions in the early sample (2003-2012) v.s. the late sample (2013-2022).

Panel A: Quarterly v.s. Annual



Panel B: Early v.s. Late

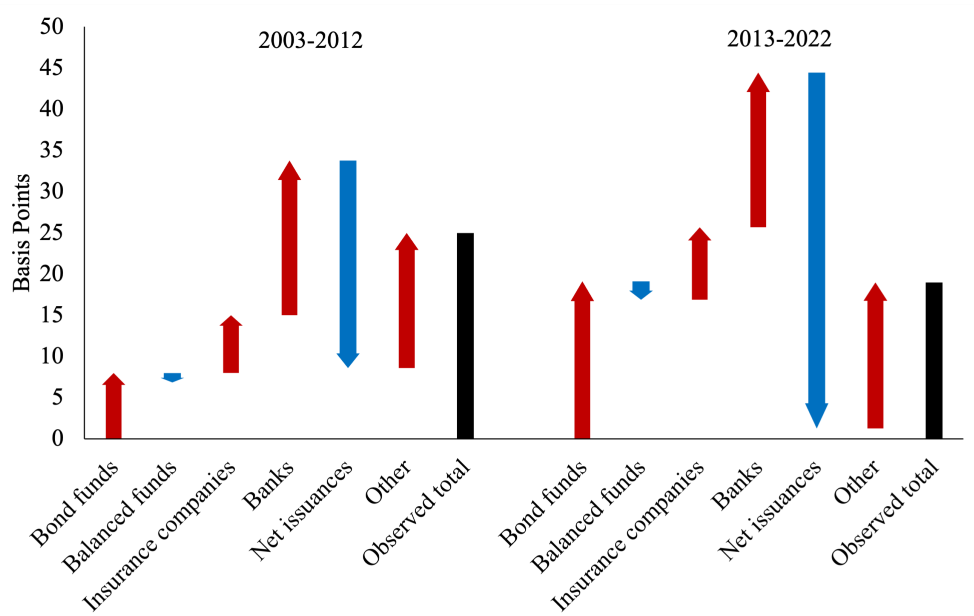
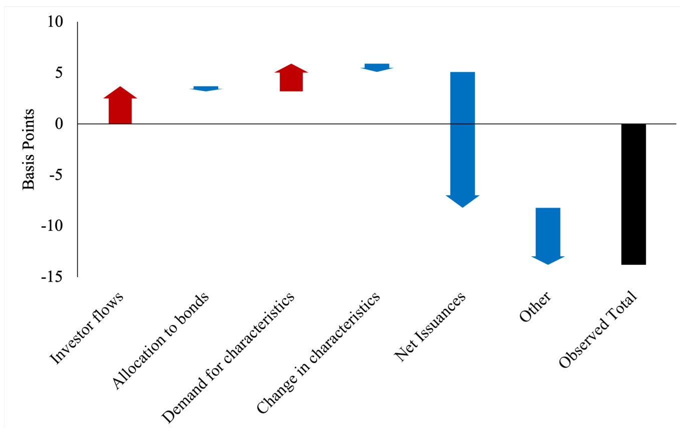
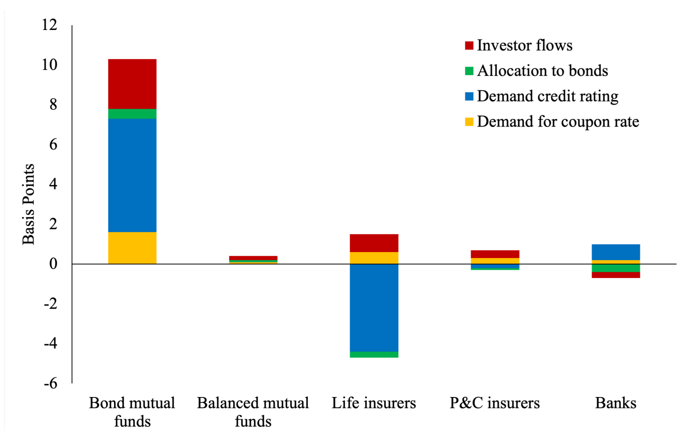


Figure 8: **Decomposition of BBB Credit Spread Sensitivity to Monetary Policy.** These figures show contributions from different channels to the monetary sensitivity of BBB-rated corporate spreads (over duration-matched Treasury yields). This is estimated as β_1 from regression (13): $\Delta y_t(c) = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \gamma X_t + \epsilon_t$ where $\Delta y(c)$ denotes changes in average BBB spreads attributable to a specific channel c to term spread according to Equation 12, Δr^{1Y} the change in one-year Treasury rate, Δq^{FED} denotes net purchases by the Fed (relative to total market outstanding), and X includes GDP growth and CPI inflation.

Panel A: By Channel



Panel B: By Investor



Panel C: By Issuer

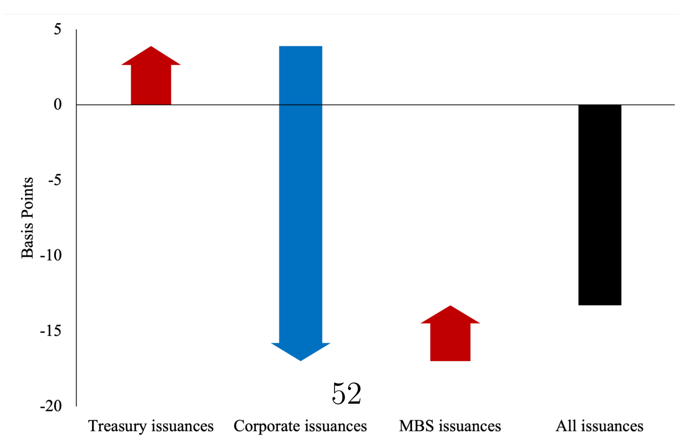
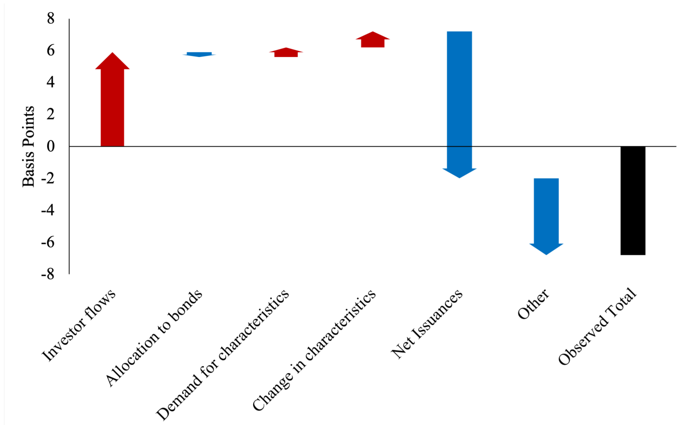
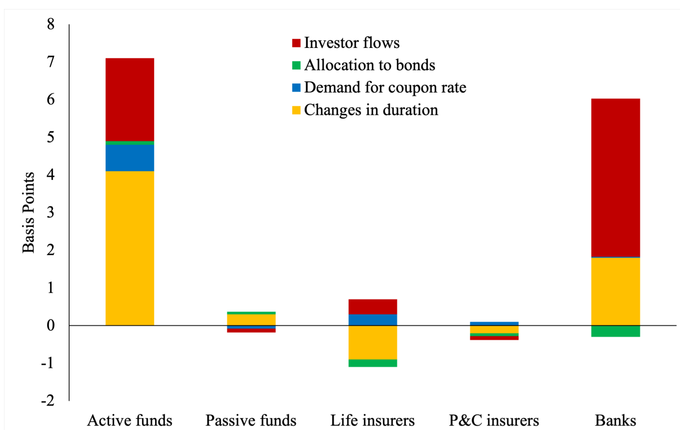


Figure 9: **Decomposition of MBS Spread Sensitivity to Monetary Policy.** These figures show contributions from different channels to the monetary sensitivity of MBS spreads (over duration-matched Treasury yields). This is estimated as β_1 from regression (13): $\Delta y_t(c) = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \gamma X_t + \epsilon_t$ where $\Delta y(c)$ denotes changes in average MBS spreads attributable to a specific channel c to term spread according to Equation 12, Δr^{1Y} the change in one-year Treasury rate, Δq^{FED} denotes net purchases by the Fed (relative to total market outstanding), and X includes GDP growth and CPI inflation.

Panel A: By Channel



Panel B: By Investor



Panel C: By Issuer

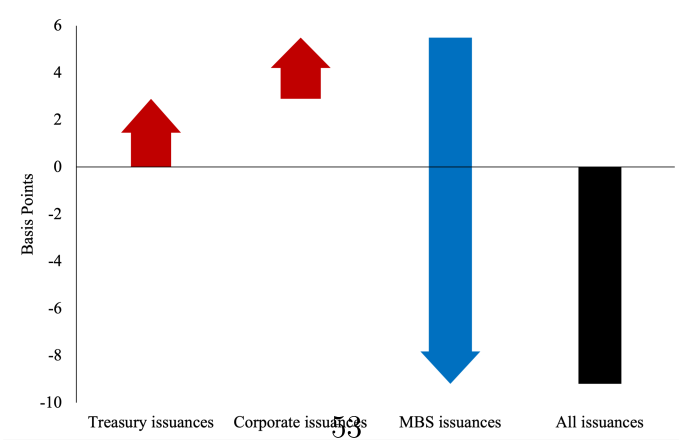


Figure 10: **Decomposition of Corporate Issuance Sensitivity to Monetary Policy.** The figure illustrates the factors driving corporate bond issuance sensitivity to monetary policy. The black bar indicates the observed sensitivity. The red bars show contributions from changes in expected short rates, investor-driven term spread changes, and investor-driven credit spread changes.

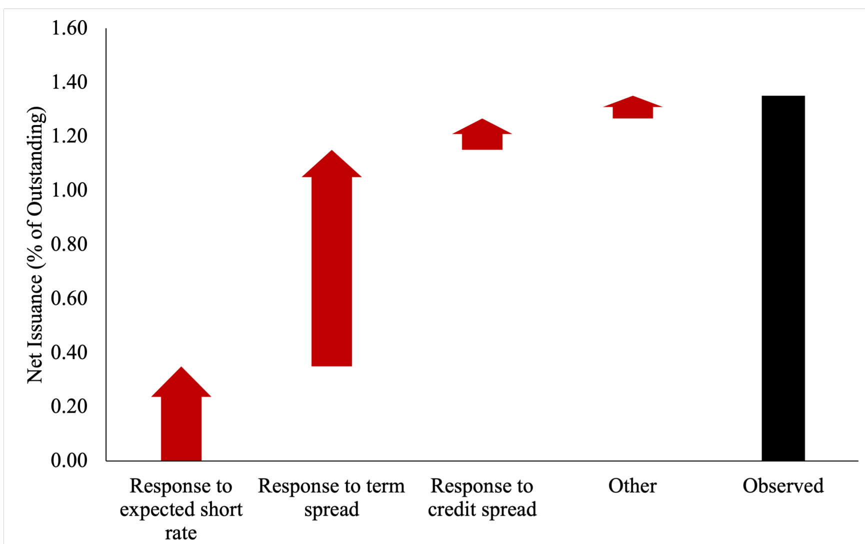
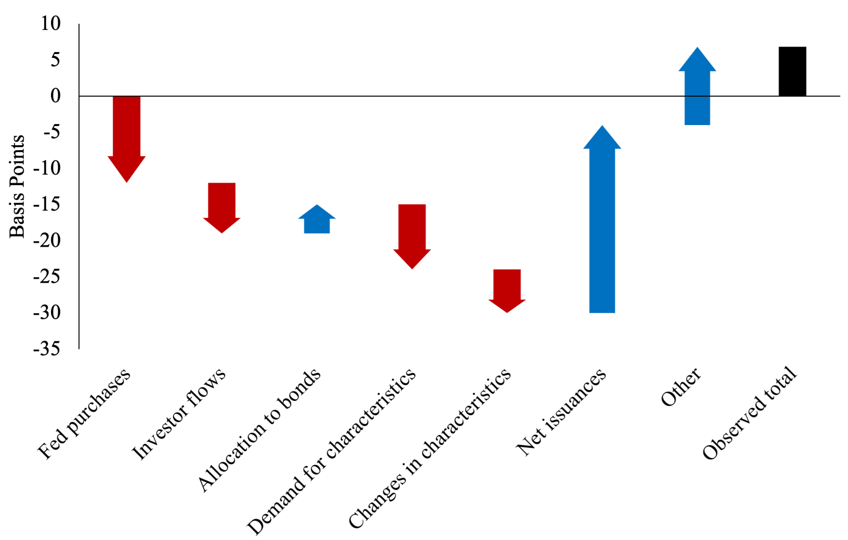
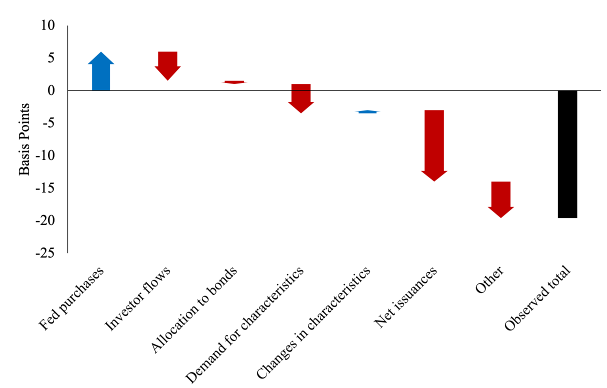


Figure 11: **Dissecting Bond Yield Sensitivity to Quantitative Easing.** These figures show contributions from different channels to the sensitivity of bond yields to net purchases by the Federal Reserve. This is estimated as β_2 from regression (13): $\Delta y_t(c) = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \gamma X_t + \epsilon_t$ where $\Delta y(c)$ denotes changes in 10-year Treasury term spread (Panel A), BBB credit spread (Panel B) or MBS spread (Panel C) to a specific channel c to term spread according to Equation 12, Δr^{1Y} the change in one-year Treasury rate, Δq^{FED} denotes net purchases by the Fed (as percentage of total market outstanding), and X includes GDP growth and CPI inflation.

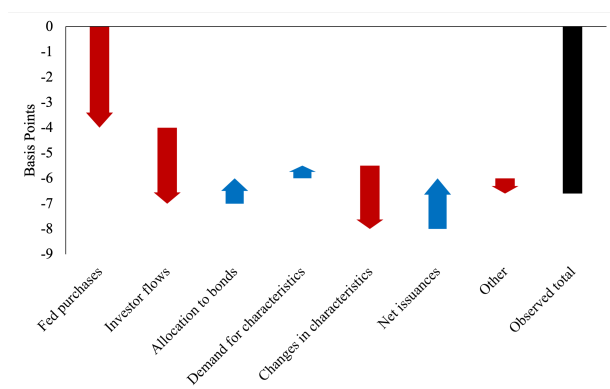
Panel A: 10-Year Term Spread



Panel B: BBB Credit Spread



Panel C: MBS Spread



Tables

Table 1: **Bond Portfolios 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, 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	P25	P50	P75
538 Treasury Bond Portfolios					
Credit Rating (AAA = 0, CCC = 6)	0.00	0.00	0.00	0.00	0.00
Duration (year)	7.34	6.22	2.94	4.82	8.39
Coupon Rate (%)	2.66	1.90	1.00	2.00	3.00
Callability	0.00	0.07	0.00	0.00	0.00
Bid-Ask Spread (%)	0.05	0.04	0.03	0.04	0.05
Amount Outstanding (bn $)	6.35	16.84	0.15	0.85	4.12
2132 Corporate Bond Portfolios					
Credit Rating (AAA = 0, CCC = 6)	2.33	1.56	1.00	2.00	3.00
Duration (year)	7.48	5.74	3.57	5.52	8.71
Coupon Rate (%)	5.02	2.30	4.00	6.00	6.00
Callability	0.11	0.31	0.00	0.00	0.00
Bid-Ask Spread (%)	0.44	0.51	0.20	0.31	0.46
Amount Outstanding (bn $)	85.54	140.83	17.04	28.10	90.99
537 Agency MBS Portfolios					
Credit Rating (AAA = 0, CCC = 6)	0.00	0.00	0.00	0.00	0.00
Duration (year)	5.31	1.66	4.04	5.62	6.63
Coupon Rate (%)	4.26	1.47	3.00	4.00	5.00
Callability	1.00	0.00	1.00	1.00	1.00
Bid-Ask Spread (%)	0.06	0.02	0.05	0.06	0.07
Amount Outstanding (bn $)	24.06	97.28	0.04	0.63	6.80

Table 2: **Portfolio Changes in Response to Monetary Policy.** These tables report $-\beta_1$ (Panel A) and β_2 (Panel B) from regression (1): $\Delta q_t = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \gamma X_t + \epsilon_t$, where Δq denotes year-over-year change in par amount held (as percentage of total bond market), change in average credit rating (AAA = 0, CCC = 6), or change in average duration (year), Δr^{1Y} denotes change in one-year Treasury rate (%), q^{FED} denotes net purchases by the Fed (as percentage of total bond market), and X includes GDP growth and CPI inflation. The regression is run separately for each investor group i and separately for Treasury bonds, corporate bonds and MBS. t-statistics are shown in parentheses.

Panel A: Response to 100 bps Drop in One-Year Treasury Rate

	ΔPar Amount (% of Outstanding)			ΔCredit Rating (AAA = 0, CCC = 6)	ΔDuration (Year)		
	Treasury	MBS	Corporate	Corporate	Treasury	MBS	Corporate
Mutual Funds	0.106	0.136	0.189	0.031	0.021	-0.234	0.031
	(2.113)	(1.495)	(3.992)	(1.399)	(0.516)	(-2.355)	(1.083)
Insurance Companies	-0.079	-0.005	0.052	-0.013	0.082	-0.325	0.125
	(-2.945)	(-0.193)	(2.232)	(-1.301)	(1.789)	(-3.026)	(3.544)
Banks	0.178	0.210	0.019		0.071	-0.255	0.136
	(2.046)	(1.924)	(2.315)		(2.241)	(-2.285)	(3.783)
Primary Dealers	0.035	0.011	0.001	-0.029	-0.092	-0.186	-0.080
	(0.306)	(0.762)	(0.683)	(-0.561)	(-0.312)	(2.047)	(-0.128)
Federal Reserve	0.125	-0.052			0.142	-0.139	
	(0.835)	(-0.641)			(3.023)	(-1.935)	
Issuance / Market	-0.237	-0.339	-0.321	0.017	0.041	-0.232	0.062
	(-0.575)	(-2.587)	(-4.837)	(1.390)	(4.001)	(-2.292)	(2.244)

Panel B: Response to 1% Net Purchases by the Federal Reserve

	ΔPar Amount (% of Outstanding)			ΔCredit Rating (AAA = 0, CCC = 6)	ΔDuration (Year)		
	Treasury	MBS	Corporate	Corporate	Treasury	MBS	Corporate
Mutual Funds	0.045	0.028	0.124	0.015	0.016	-0.129	0.030
	(3.883)	(1.483)	(1.725)	(1.830)	(2.466)	(-2.505)	(2.594)
Insurance Companies	0.028	0.000	0.033	-0.004	0.054	-0.181	0.086
	(5.139)	(0.150)	(4.252)	(-1.071)	(1.451)	(-2.623)	(1.891)
Banks	0.121	0.143	0.004		0.114	-0.155	0.057
	(6.937)	(1.592)	(1.668)		(3.867)	(-2.945)	(1.465)
Primary Dealers	-0.041	-0.013	-0.001	-0.008	0.099	-0.103	-0.080
	(-2.627)	(-2.811)	(-0.688)	(-0.124)	(1.376)	(-2.036)	(-0.214)
Federal Reserve	0.547	0.457			-0.052	-0.077	
	(7.231)	(7.272)			(-4.816)	(-1.632)	
Issuance / Market	-0.767	-0.417	-0.177	0.005	0.018	-0.129	0.043
	(-8.282)	(-1.503)	(-5.612)	(0.976)	(6.639)	(-2.571)	(2.245)

Table 3: **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 v.s. passive), 20 insurance company groups (by life v.s. 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.

Panel A: 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

Panel B: 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

Panel C: 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 4: **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

Internet Appendix

A Details on portfolio holdings data

We build a comprehensive dataset of bond holdings at a granular level. Our dataset covers five types of bond investors: mutual funds, insurance companies, banks, primary dealers, and the Federal Reserve. Data on mutual fund holdings come from Morningstar. The data contain monthly CUSIP-level holdings from 2002 to present. We include both U.S.-domiciled funds and foreign funds that focus on U.S. assets, indicated by base currency.[22] Our definition of mutual funds include exchange-traded funds (ETFs) and variable annuity funds, which are also open-end funds that share similar investor flow dynamics. We restrict to funds whose broad investment category is fixed income or allocation, so their investment in bonds is meaningful.

Data on insurance company holdings at the CUSIP level come from NAIC statutory filings, Schedule D. Quarterly holdings are inferred 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 hold small quantities of non-cash assets.

Data on bank holdings come from FFIEC Reports of Condition and Income (Call Reports). Each bank reports holdings across bond classes — Treasury, agency obligations, municipal, MBS, ABS, other domestic debt securities (we designate this bond class as banks' corporate bond holdings), and other foreign debt securities — 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 implemented.

[22] Most of these foreign funds are domiciled in tax havens such as Ireland and Luxembourg.

B Details on debt securities data

We collect data on three classes of bonds, which together span virtually the entire U.S. taxable bond market: Treasury bonds, corporate bonds, and agency mortgage-backed securities (MBS).[23] These three bond classes share similar characteristics, they share the same investor base, their yields are tightly linked, and therefore we argue that they should be jointly determined in equilibrium. As elaborated later, having a broad set of bonds is essential for us to capture some transmission channels that would have been silent otherwise, such as 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 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 144A bonds and exclude equity-linked bonds (e.g. convertible bonds), floating-rate bonds and puttable bonds. Data on agency MBS come from Refinitiv. We focus on agency pools and TBAs and exclude CMOs.

Bond yield is approximated based on continuous compounding and coupon payout: $P = e^{-(y-c)T}$, where c denotes coupon rate and T denotes option-adjusted duration. This approximation makes it computationally efficient to translate between bond yields and bond prices, which is particularly useful for deriving market-clearing yields during the counterfactual analyses, especially for bonds with complex cash flows, such as MBS.

We measure credit rating as the median rating from S&P, Moody's, and Fitch. All Treasury bonds are AAA-rated, all agency securities are rated AA or higher, and 98% of corporate bonds are rated.[24] We convert letter rating to a numeric scale from 0 (AAA) to 6 (CCC or lower).

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 through simulation. Specifically, for given values of macroeconomic variables such as one-year Treasury rate and GDP growth, 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, we follow the convention

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

[24] Bonds without credit rating are dropped. Our main results are robust to treating unrated bonds as having the lowest rating.

and calculate bid-ask spreads using trades.[25]

We make extensive efforts in ensuring the accuracy of amount outstanding. The timing 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 factor history from Refinitiv, and assume that they represent their respective cohorts. For resecuritizations, such as Treasury strips and agency re-securitized mortgage-backed security (megas), we make sure not to double count them when calculating total amount outstanding.

[25]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.

C Details on estimating the expected short rate component of bond yields

We follow Nagel and Xu (2024) in estimating the expected short rate component of bond yields at different tenors. We assume that forecasters model the short rate process as AR(1):

$$i_{t+1} - \mu = \gamma(i_t - \mu) + \eta_{t+1}$$

which implies:

$$E_t i_{t+n+1} - \mu = \gamma(E_t i_{t+n} - \mu)$$

where $E_t i_{t+n}$ denotes the time t median forecast of short rate i at n quarters ahead. We assign μ to be the long-range forecast of short-term interest rate between 7 to 11 years ahead and estimate γ through an OLS regression in the cross section of forecast horizon n (without constant). For example, to estimate γ as of 2018Q1, we take forecasts of 1-quarter ahead, 2-quarter ahead, ..., 5-quarter ahead, subtract the long-range forecast between 7 to 11 years ahead, and run an autoregressive regression with 4 observations. We thank Nagel and Xu (2024) for directly providing us with estimated μ and γ, and the expected short rate component of the yield of a bond maturing in T quarters is:

$$y_f^T = \frac{1}{T}\sum_{n=1}^{T} E_t i_{t+n} = \frac{1}{T}\sum_{n=1}^{T}(\gamma^{n-1}(E_t i_{t+1} - \mu) + \mu)$$

D Details on estimating random demand coefficients

Our procedure of estimating random coefficients follows 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 5 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:

$$\min_\theta g(\theta)'Wg(\theta)$$

where W is the weighting matrix.

E Decomposition of transmission across term structure and credit spectrum

Panel A of Figure A8 reports the decomposition of demand- and supply-side channels across maturity buckets, which reveals that the importance of a channel is heterogeneous across the term structure. 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.

Duration changes mainly amplify monetary sensitivity in the 5-10 year range. This is because callable bonds, such as MBS, have a median duration of 5.62 (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 net issuances 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 reduces their yields.

Panel B of Figure A8 shows monetary sensitivity across the credit spectrum. 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 monetary sensitivity of A-rated bonds but decreases the monetary 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 bonds with lower regulatory charges, and A-rated bonds offer the highest yields while still having relatively low regulatory charges (Becker and Ivashina, 2015; Li, 2024). Net issuances 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.

F State-dependent effects of transmission channels

The early v.s. late sample analysis in Panel B of Figure 7 suggests 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 4.7), 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 A4. We focus on the 10-year term spread and the four channels that ranked the highest in our previous decomposition exercise: bond fund flows, insurer demand for duration, changes in 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 corporate bond 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, as shown in Figure 7. 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.

G The effect of investor composition on monetary transmission

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 A5. 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 naturally 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.

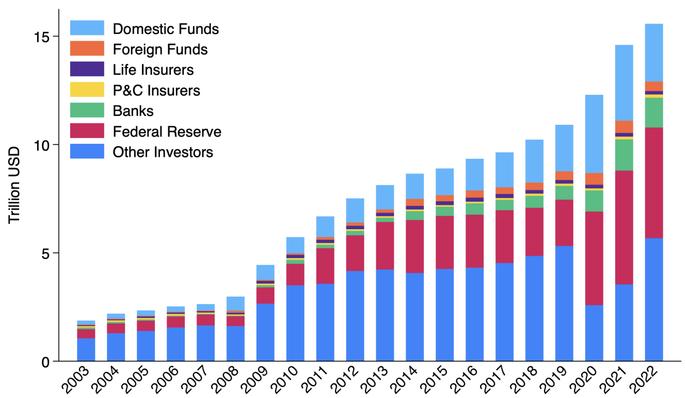
Panel B of Table A5 focuses on 5-year BBB spread sensitivity. Similarly, changes in the relative AUM of bond funds and life insurers will change the relative weights of the underlying transmission channels. In response to monetary tightening, bond funds tend to decrease credit risk-taking and reduce 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.

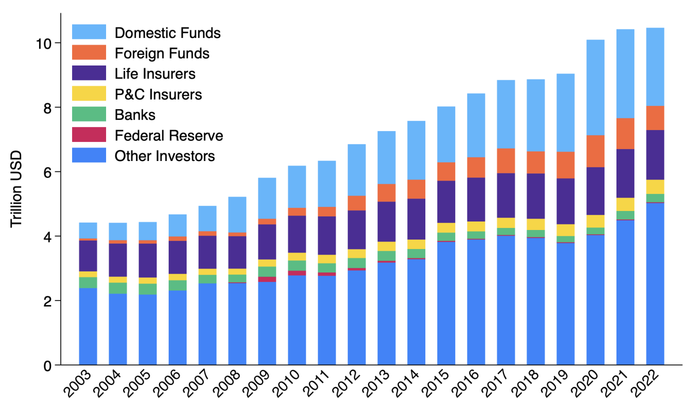
H Additional Figures

Figure A1: **Bond Ownership.** The figures show investor composition for Treasury bonds, corporate bonds, and agency MBS. We restrict to straight bonds (including callable bonds) with more than one year to maturity.

Panel A: Treasury Bonds



Panel B: Corporate Bonds



Panel C: Agency MBS

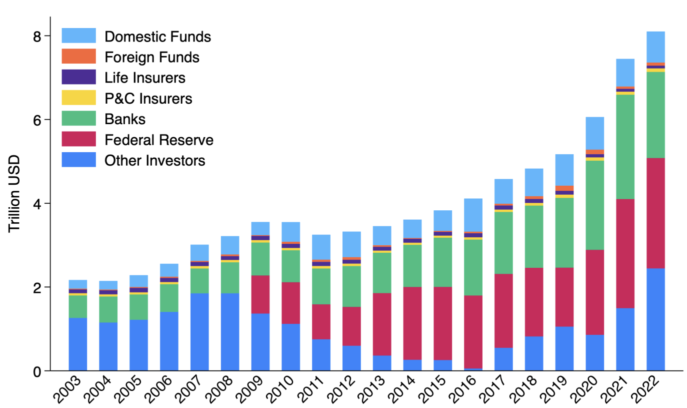
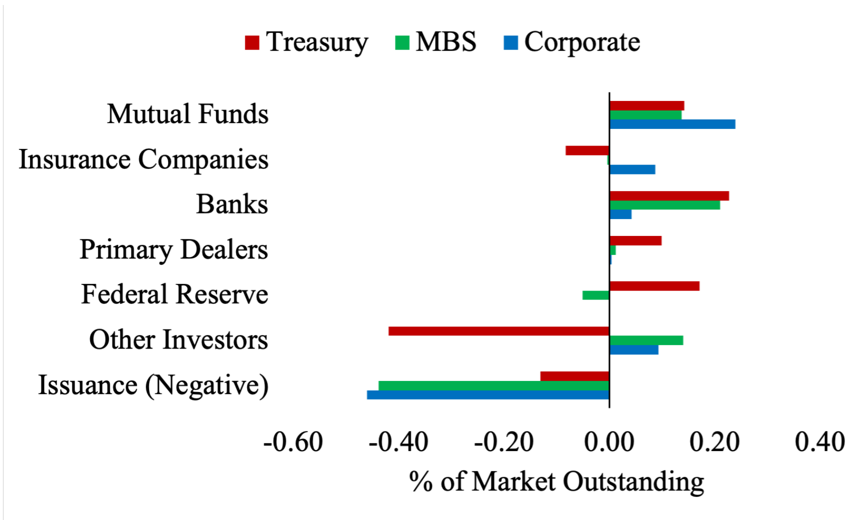
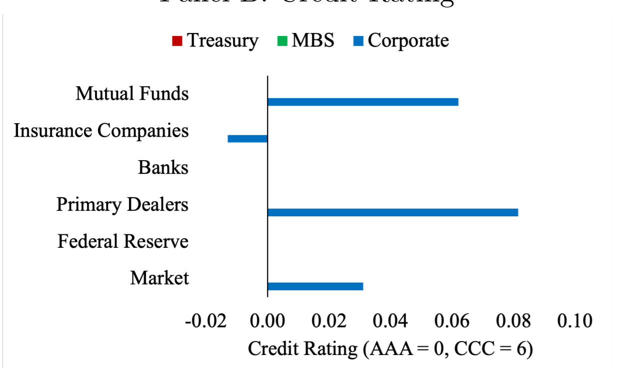


Figure A2: **Portfolio Changes to Monetary Policy Shocks.** These figures report $-\beta_1$ from regression (1): $\Delta q_t = \alpha + \beta_1 \Delta r_t^{1Y} + \beta_2 \Delta q_t^{FED} + \gamma X_t + \epsilon_t$, where Δr_t^{1Y} is further instrumented with Bauer and Swanson (2023) monetary policy shocks. The regression is run separately for each investor group and separately for Treasury bonds, corporate bonds and MBS.

Panel A: Amount



Panel B: Credit Rating



Panel C: Duration

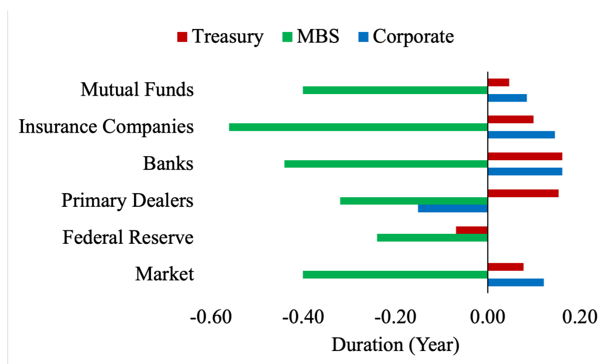


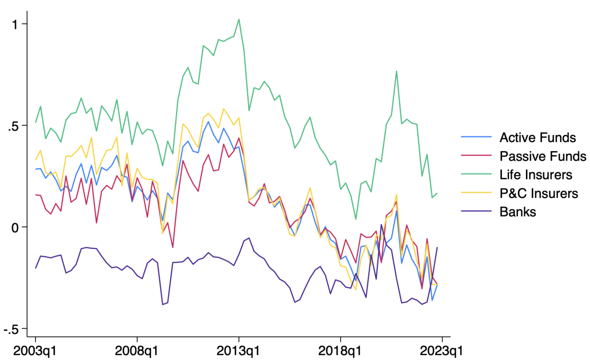
Figure A3: **Estimated Demand Coefficients.** These figures display estimated demand coefficients (μ, Σ) on credit rating (from 0 AAA to 6 CCC), duration (year), coupon rate (%), and bid-ask spread (%), using the procedures described in Section 4.6.

Panel A: Mean Coefficient μ

Credit Rating

Duration

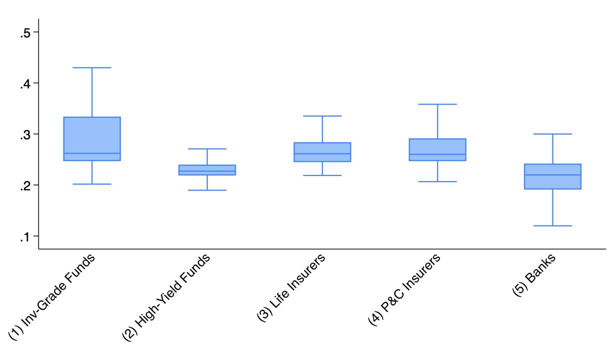
Coupon Rate



Bid-Ask Spread

Panel B: Variation in Coefficient Σ

Credit Rating



Duration

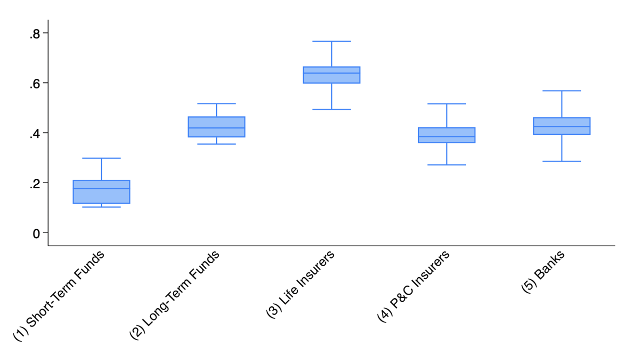
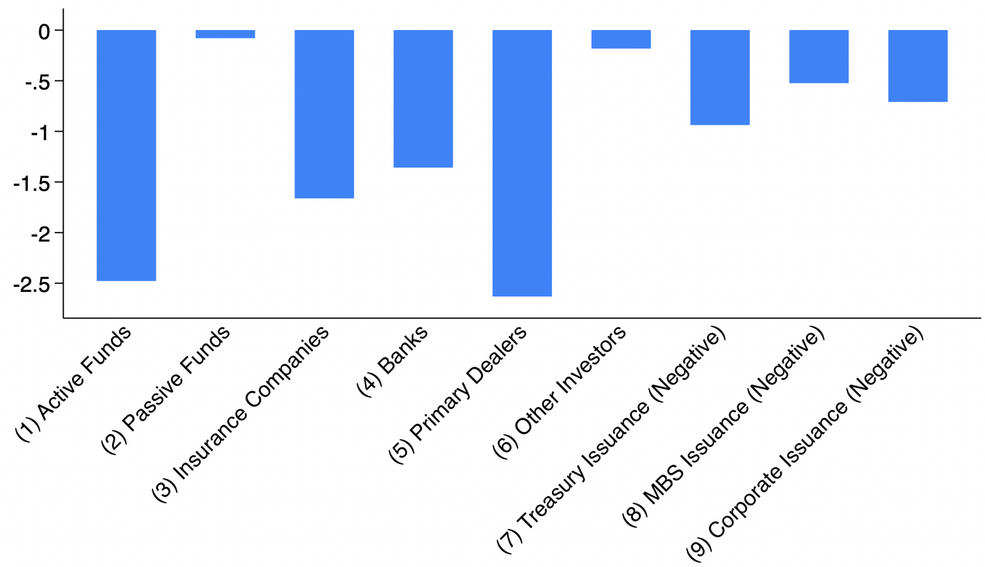


Figure A4: **Estimated Elasticities across Sectors.** The figures show our estimated elasticities across different investor groups and bond issuers.

Panel A: Price Elasticity



Panel B: Contribution to Market Elasticity

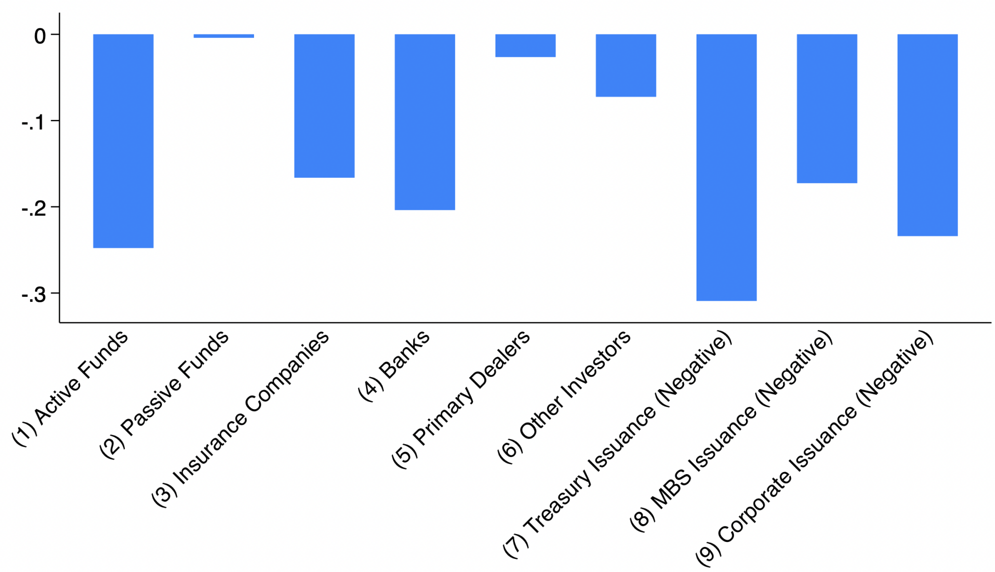


Figure A5: **Further Decomposition of 10-Year Treasury Term Spread Sensitivity to Monetary Policy.** These figures show contributions from different channels to the monetary sensitivity of 10-year Treasury term spread (over expected short rates), according to our method described in Section 5.

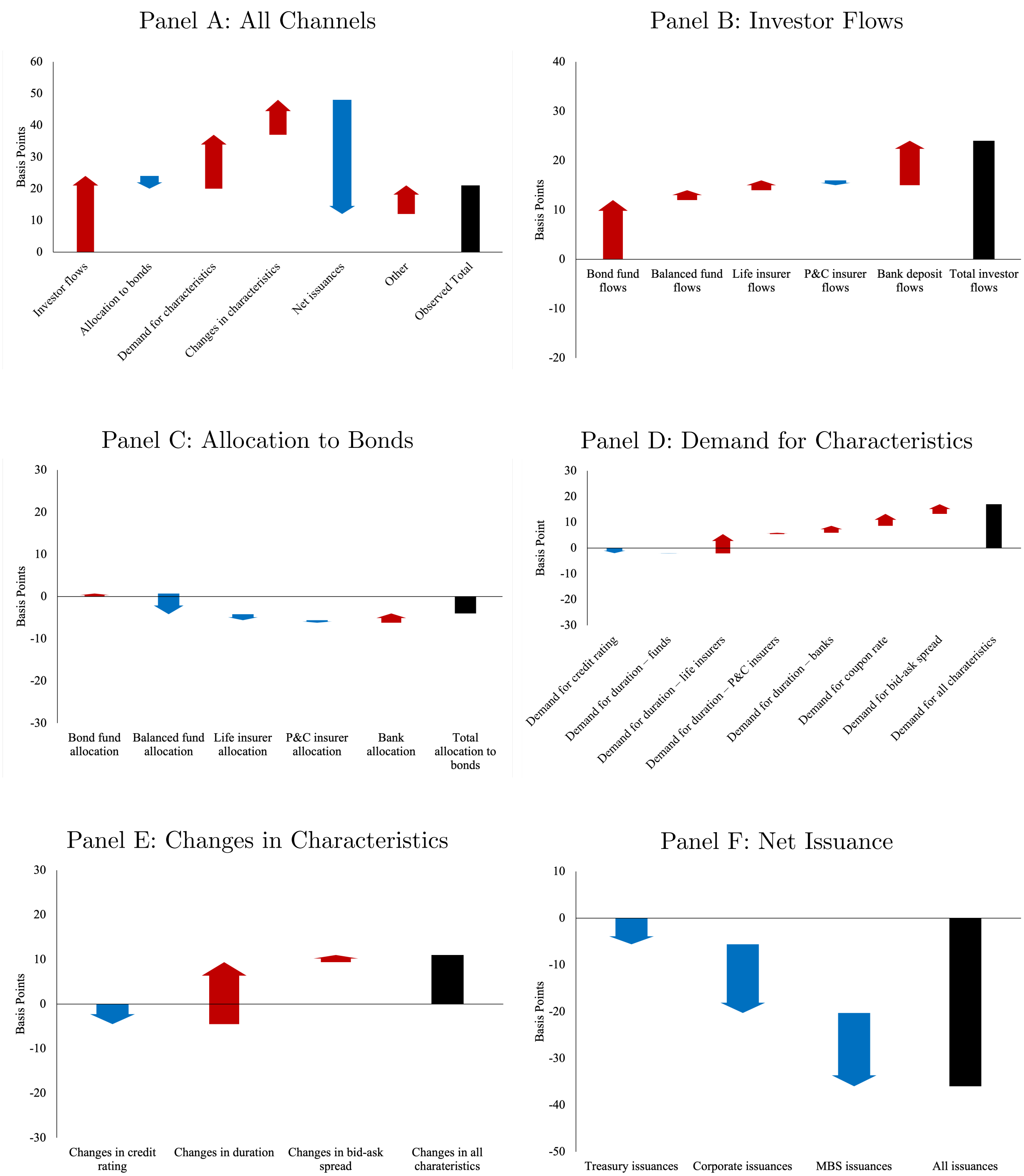


Figure A6: **Further Decomposition of BBB Credit Spread Sensitivity to Monetary Policy.** These figures show contributions from different channels to the monetary sensitivity of BBB-rated corporate spread (over duration-matched Treasury yield), according to our method described in Section 5.

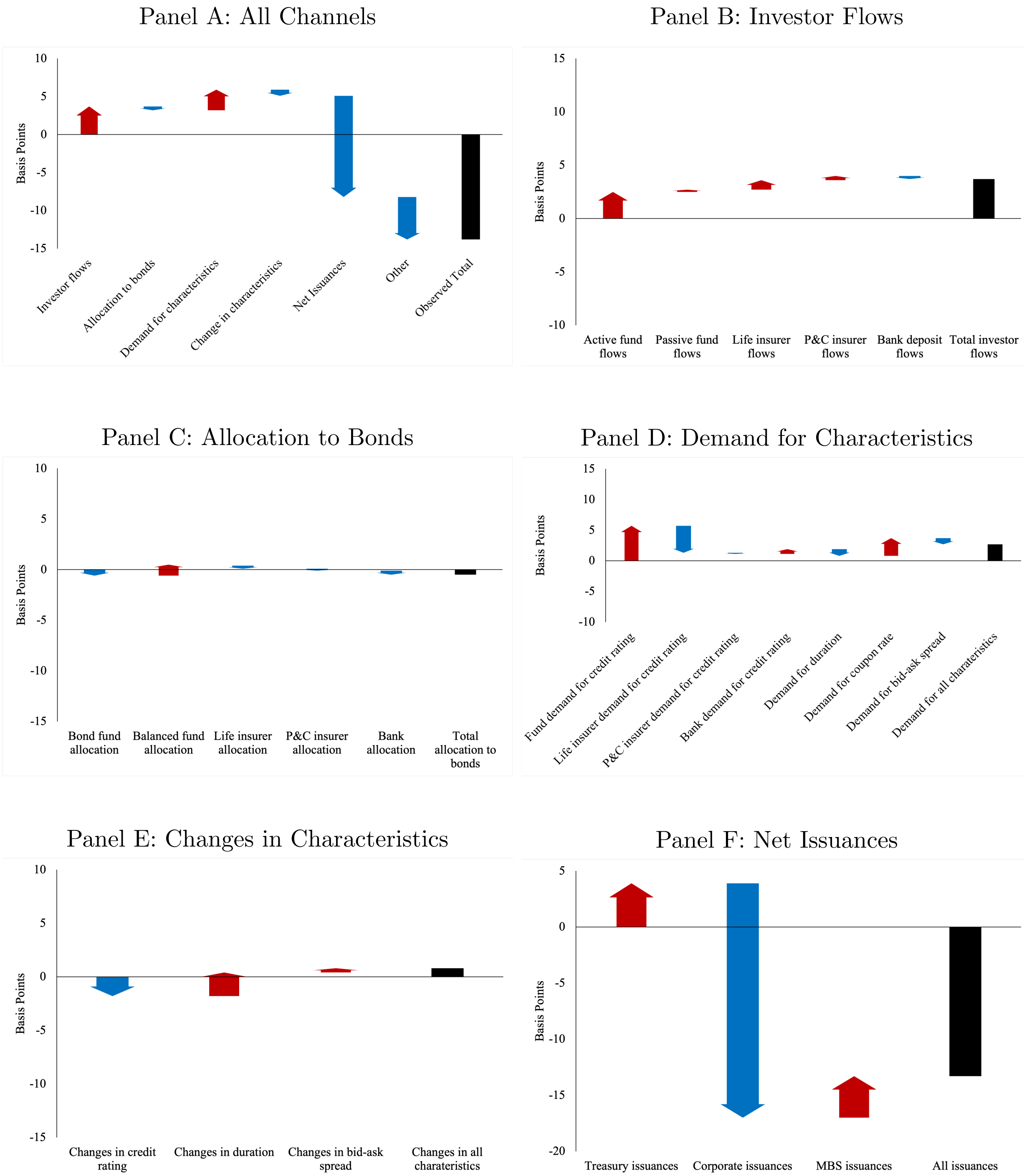


Figure A7: **Further Decomposition of MBS Spread Sensitivity to Monetary Policy.** These figures show contributions from different channels to the monetary sensitivity of MBS spread (over duration-matched Treasury yield), according to our method described in Section 5.

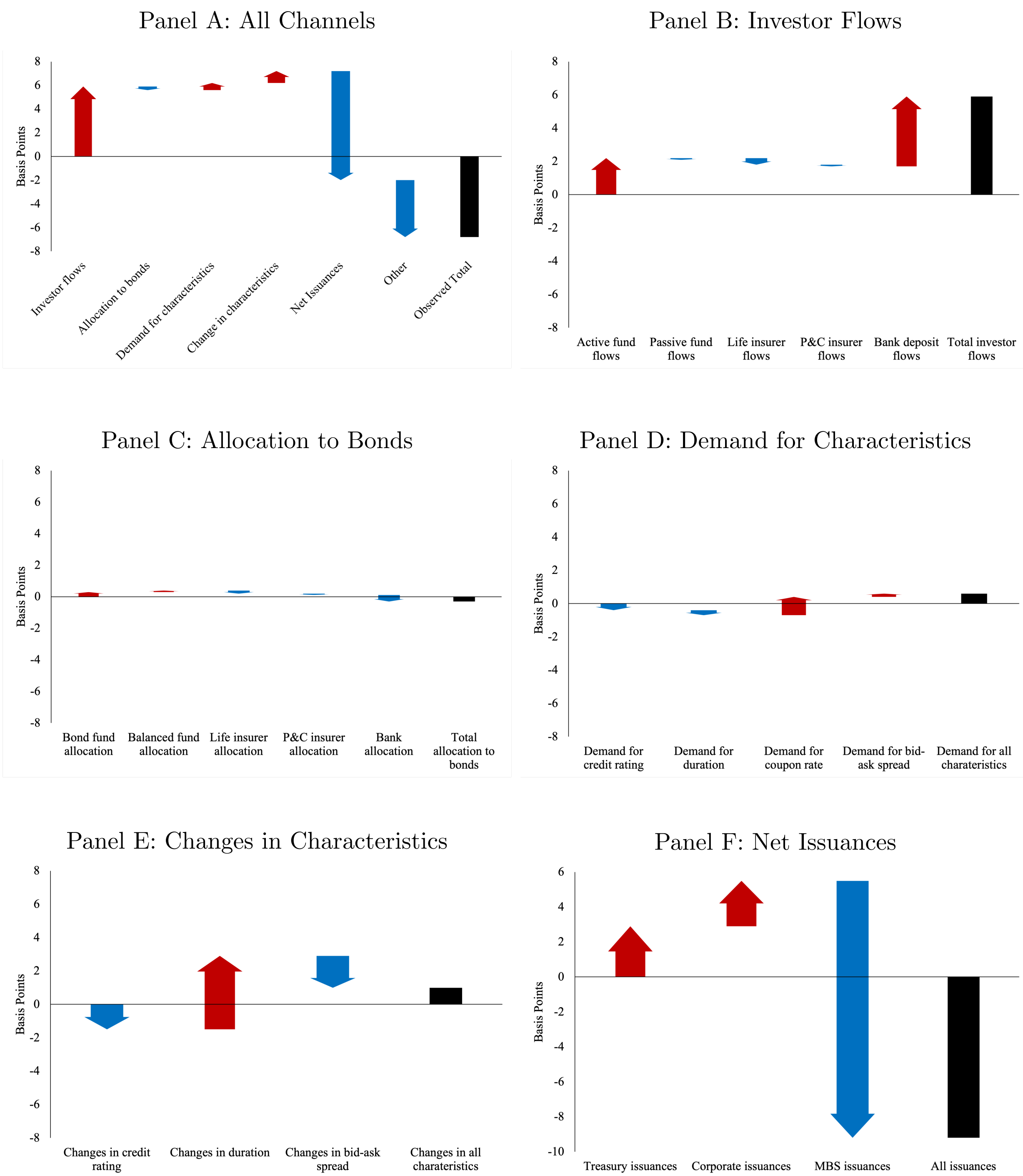
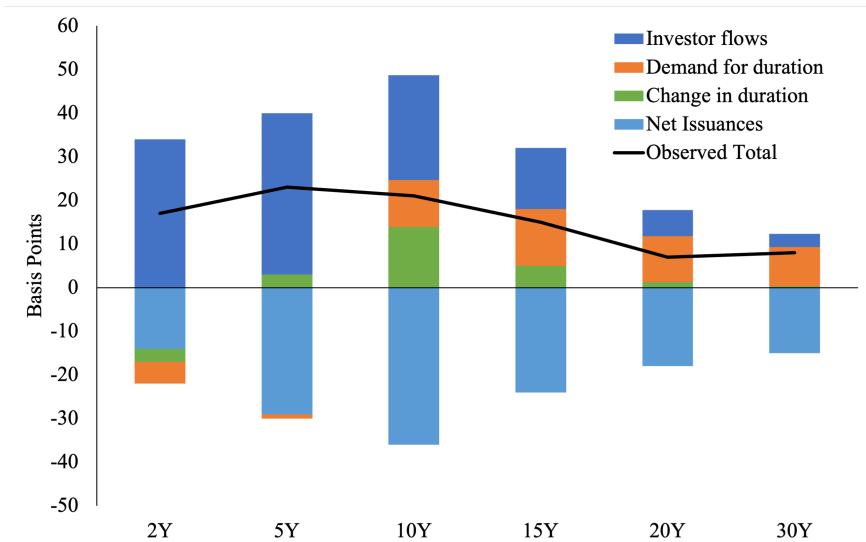
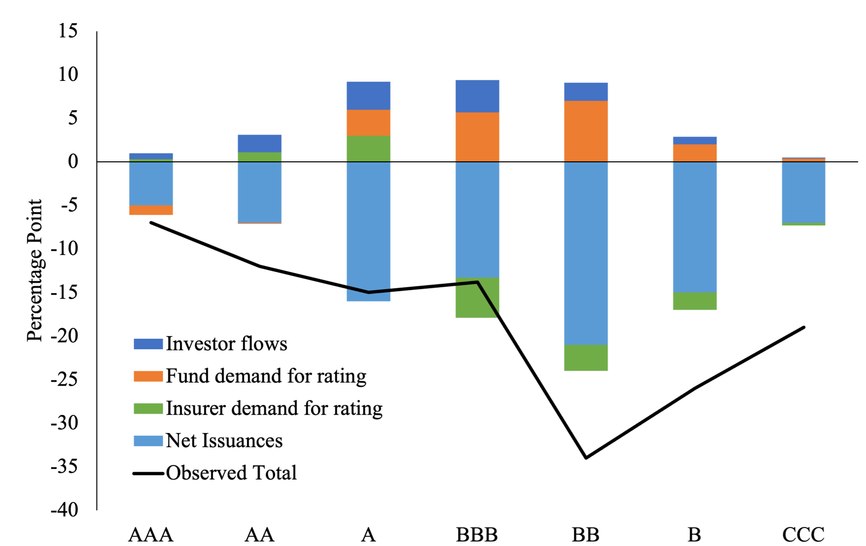


Figure A8: **Dissecting Monetary Sensitivity across Term Structure and Credit Spectrum.** These figures show contributions from different channels to the monetary sensitivity of bond yields across the term structure (Panel A) and across the credit spectrum (Panel B), according to our method described in Section 5.

Panel A: Term Structure



Panel B: Credit Spectrum



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

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: **Own- and Cross-Price Elasticities in Fixed Coefficient Logit Model.** These tables are the counterparts of Table 4 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 A3: **Estimated Elasticity of Aggregate Net Issuances.** The table shows estimated elasticities of net issuances of Treasury bonds, corporate bonds, and agency MBS, according to the following regression: $\Delta s_t = \kappa \widehat{\Delta y}_t + \zeta X_t + \nu_t$ where Δs denotes aggregate net issuances (scaled by aggregate outstanding), $\widehat{\Delta y}$ denotes yield changes instrumented with flow-induced trading from Equation 9, and X includes aggregate bond characteristics and macroeconomic variables. t-statistics are reported in parentheses. *, **, and *** denote p-values less than 0.10, 0.05, and 0.01, respectively.

	Net Issuance (% of Outstanding)		
	Treasury	Corporate	MBS
	(1)	(2)	(3)
Instrumented ΔYield (%)	0.963*	1.667**	2.241*
	(1.922)	(2.325)	(1.783)
Credit Rating (AAA = 0, CCC = 6)		2.596	
		(0.567)	
Duration (Year)	9.162**	8.138***	-0.543
	(2.214)	(4.269)	(-0.910)
Coupon Rate (%)	2.402	2.040	4.783**
	(1.524)	(1.255)	(2.022)
Bid-Ask Spread (bps)	-5.113**	-0.015	2.595
	(-2.211)	(-0.784)	(1.410)
GDP Growth (%)	0.202	-0.194***	-0.277***
	(0.562)	(-2.962)	(-3.060)
CPI Inflation (%)	-2.356*	-2.913***	3.134***
	(-1.732)	(-7.293)	(5.197)
Standard Errors		Newey and West (1994)	
Observations	80	80	80
R2	0.121	0.493	0.267

Table A4: **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 elasticities ($\{\alpha\}$) 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

Yield Coeff	∂Bond Fund Flow / ∂1Y Treasury Rate: -4.0%	-6.0%	-8.0%	-12.0%	-16.0%
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

Yield Coeff	∂Insurer Demand for Duration / ∂1Y Treasury Rate: -0.06	-0.09	-0.12	-0.16	-0.24
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

Yield Coeff	∂MBS Duration / ∂1Y Treasury Rate: 0.10	0.15	0.20	0.30	0.40
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 Issuance

Yield Coeff	∂Corporate Bond Outstanding / ∂1Y Treasury Rate: -2%	-3%	-4%	-6%	-8%
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 A5: **The Dependency of Monetary Transmission on Investor Composition.** The tables show our estimated monetary sensitivity of term spread (Panel A) and 10-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: 10Y Treasury Term Spread

	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: BBB Credit Spread

	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