Investors' Interest Rate Risk Exposure: Evidence from Corporate Bond Mutual Fund Flows*

Jing-Zhi Huang[†] Peipei Li[‡] Yuan Wang[‡] Xiangkun Yao[§]

Licheng Zhang[‡]

July 18, 2023

Abstract

This paper employs data on corporate bond mutual fund flows to study investors' exposure to interest rate risk. We document that following a decrease in the interest rate, investment-grade bond funds receive large inflows whereas this is not the case for high-yield bond funds. We show that this is because investment-grade bonds have a longer duration than high-yield bonds and are primarily exposed to interest rate risk, while high-yield bonds are mostly exposed to credit risk. Moreover, as lower rates lead to lower yields, investors buy longer-maturity bonds in order to preserve yield targets. In contrast, when the interest rate becomes higher, investors move away from long-term bond funds to short-term bond funds. A higher interest rate implies higher interest rate risk, leading to more capital losses for long-term bonds.

JEL Codes: E52, G11, G23

Keywords: Corporate bond mutual funds, mutual fund flows, reaching for yield, interest rate risk, credit risk

*We are grateful to Patrick Brandt, Bing Han, Dong Li, Victor Valcarcel, and especially Irina Panovska, as well as participants at UT Dallas Economics Brownbag, SUSTech Finance Brownbag, the 2022 Beijing Five-Star Workshop in Finance, and seminar participants at the University of Delaware for their helpful comments and suggestions. An earlier version of this paper is circulated under the title "Bond Investments under Low Interest Rates: Evidence from Corporate Bond Mutual Fund Flows."

[†]Smeal College of Business, Penn State University, University Park, PA 16802, USA; jxh56@psu.edu.

[‡]School of Business, Southern University of Science and Technology, Shenzhen, China lipp@sustech.edu.cn;wangy36@sustech.edu.cn; zhanglc3@sustech.edu.cn.

[§]School of Finance, Nankai University, Tianjin, China; xiangkun.yao@nankai.edu.cn

1 Introduction

During the 2008 financial crisis, the Federal Reserve (Fed) moved the federal funds rate (FFR) down to the 0 to 0.25 percent range for the first time, which is also known as the zero lower bound (ZLB) policy. It stayed at the ZLB until the end of 2015, and again in early 2020, the Fed lowered the FFR to ZLB in response to the COVID-19 pandemic. However, the low interest rate environment ended in 2022, when the Fed aggressively raises the federal funds rate in order to fight inflation. As shown by Hu, Pan, Wang, and Zhu (2022), the Federal Open Market Committee (FOMC) announcement together with other macroeconomic announcements all have significant impacts on financial markets. In this paper, we thus study both the low interest rates and rising interest rates on investors' investment decisions.

We first examine whether corporate bond mutual fund investors reach for yield in a low-interest rate environment. A large literature shows that low interest rates can spur investors to reach for yield [1]. For example, Rajan (2006) suggests that low interest rates induce investors to move into risky assets in a bid to boost total returns. Hau and Lai (2016) show that lower interest rates incentivize investors to shift portfolios from the money market to the equity market.

However, this paper instead finds that in response to the Fed's lower interest rate policy, there are large inflows to investment-grade bond funds, while the high-yield bond funds are not responsive. In other words, investors do not seem to reach for yield. We show that bond investors, however, still reach for yield, but they do that by taking duration risk rather than credit risk. We explore the mechanism behind this, and the key lies in their different interest rate risk exposures. Investment-grade funds have a much longer duration than high-yield funds and are primarily exposed to interest rate risk. While high-yield funds face little interest rate risk but are much more exposed to default and credit spread risk. Therefore,

[1] Reaching for yield denotes investors' propensity to buy riskier assets to achieve higher yields (Becker and Ivashina, 2015).

high-yield bond funds are not as sensitive to the change in interest rates as investment-grade bond funds. When interest rate becomes lower, interest rate risk also declines, which makes investment-grade bond funds more attractive, and thus gain inflows.

In terms of the effects of rising interest rates, we document that during periods of monetary policy tightening, there are outflows from long-term investment-grade bond funds and inflows to short-term bond funds. Higher interest rates imply higher interest rate risk, thus these long-term bond funds suffer more capital losses than short-term funds. That explains why investors move away from long-term bond funds to short-term bond funds.

Our analysis starts with aggregate time-series data on mutual fund flows, which is monthly data from January 2016 to March 2022. We apply structural vector autoregression (SVAR) to estimate the impulse responses of both investment-grade bond funds and high-yield bond funds to an expansionary monetary policy shock. We identify the monetary policy shock with sign restrictions (Uhlig, 2005, 2017). Specifically, our identifying assumption is that an expansionary monetary policy shock is associated with a decrease in the federal funds rate, an increase in industrial production growth, and an increase in CPI growth. We find that following an expansionary monetary policy shock, investment-grade funds receive inflows, while the response of high-yield bond fund flows moves around zero, suggesting that high-yield bond funds are not responsive to monetary policy shocks.

A natural question is why investment-grade fund flows and high-yield fund flows show such different patterns in response to a lower interest rate. We hypothesize that the answer lies in their distinct interest rate risk exposures. We test this hypothesis by relying on fund-level panel data, which is from September 2000 to June 2020, and it provides details of individual funds' characteristics, such as fund returns, fund maturity, and distribution yields. Specifically, we quantify the interest rate sensitivity for investment-grade and high-yield funds, respectively. Indeed, we find that investment-grade funds have larger interest rate sensitivity than high-yield funds. This should be no surprise, given that investment-grade bonds are primarily exposed to interest rate risk, while high-yield bonds face little interest risk but are much more exposed to default and credit spread risk.

We formally examine this argument by investigating the effects of credit risk and duration risk on investors' responses to a lower interest rate. We find that credit risk has negative effects on both investment-grade fund flows and high-yield fund flows. In terms of the magnitude and statistical significance, our results suggest that the credit risk effects are larger for high-yield bond funds, which is consistent with Huang and Huang (2012), who also find that credit risk accounts for a large fraction of the yield spreads for high-yield bonds. As for the duration risk, we find that in response to a lower interest rate, there are more inflows to these longer-maturity investment-grade bond funds, while investors in high-yield funds do not respond. Why do investors move to longer-maturity investment-grade bond funds? When the interest rate turns lower, the bond price increases, which implies lower yields and interest rate risk. Investors thus tend to buy longer-maturity bonds in order to achieve the same level of yield target. Both results together confirm our argument.

Some may argue that there is an alternative explanation for the inflows to these high-quality investment-grade funds, that is, investors' flight to safety. Since investment-grade bonds are much safer than high-yield bonds, do the inflows to investment-grade bonds suggest that bond investors fly to safety? In addition, there might be a concern that the flows are driven by the Fed's information effects but not necessarily the change of interest rates, where an easing monetary policy communicates that the state of the economy is weaker than the public had expected (Romer and Romer, 2000; Nakamura and Steinsson, 2018; Jarociński and Karadi, 2020). If so, investors may become pessimistic and buy more safe assets instead of high-yield bonds.

We first test whether flights to safety alter our findings. Following Baele, Bekaert, Inghelbrecht, and Wei (2020), we identify flight-to-safety periods using a Markov regime-switching model (Hamilton, 1989). Furthermore, as liquidity plays a significant role in driving bond flows (Beber, Brandt, and Kavajecz, 2009), we define flight-to-safety periods based on the corporate bond market liquidity index (Dick-Nielsen, Feldhütter, and Lando, 2012). We find that flight-to-safety periods do not alter the relationship between fund flows and changes in the federal funds rate, that is, the flow patterns are not driven by investors' flights to safety.

We then test whether the inflows to investment-grade bond funds are driven by Fed information effects. Specifically, we use the identified central bank information (CBI) shocks of Jarociński and Karadi (2020) to capture the Fed information effects. Our results suggest that the Fed's information effects do not contribute to inflows of investment-grade bond funds. Instead, the Fed's pure interest rate policy drives these fund flow patterns.

Finally, as the Fed began to raise interest rates in 2022, we then study the effects of rising interest rates on investment-grade fund flows. Following the increase in interest rates, bond prices decline, which implies higher interest rate risk. We find that during monetary tightening in 2022, investors move away from long-term bond funds to short-term funds. This is also because of their different interest rate risk exposures. Longer maturity bonds face higher duration risk, which leads to more losses.

The remainder of this paper is organized as follows. Section 2 summarizes the related literature. Section 3 describes the data. Section 4 estimates the impulse responses of fund flows to monetary policy shocks. Section 5 explores the panel regression results for investment-grade and high-yield funds. Section 6 tests investors' flights to safety and the Fed's information effects. Section 7 studies the effects of rising interest rates on fund flows. Section 8 conducts robustness checks. Section 9 concludes the paper.

2 Related literature

This paper connects to several strands of literature. First, this paper is related to studies on interest rate risk exposure (Faulkender, 2005; Begenau, Piazzesi, and Schneider, 2015; Hoffmann, Langfield, Pierobon, and Vuillemey, 2019; Vuillemey, 2019; Gomez, Landier, Sraer, and Thesmar, 2021; Drechsler, Savov, and Schnabl, 2021). However, these papers study banks' or firms' exposure to interest rate risk. This paper instead focuses on investors' interest rate risk exposure. We find that when interest rates become lower, investment-grade bond mutual funds gain more attraction than high-yield funds, moreover, investors tend to buy longer-maturity investment-grade funds. In contrast, following the increase in interest rates, investors move away from long-term funds to short-term funds. Our results show the significance of interest rate risk exposure in monetary policy transmission, which also offers empirical support to the interest rate exposure channel of monetary policy transmission (Woodford, 2003; Auclert, 2019).

Second, this paper also connects to the large literature on reaching for yield (Becker and Ivashina, 2015; Di Maggio and Kacperczyk, 2017; Choi and Kronlund, 2017; Lian, Ma, and Wang, 2019; Campbell and Sigalov, 2022), as well as the reaching for income phenomenon documented by Daniel, Garlappi, and Xiao (2021). In contrast to these papers on documenting reach for yield, we instead find that investors may not always reach for yield, in the sense towards higher-yield bond funds. Besides reaching for yield, interest rate risk effects may play a more important role in bond investors' investment behavior.

In addition, our paper shows similarity to the studies examining the effects of interest rates on bond investors' portfolio choices. Hanson and Stein (2015) find that yield-oriented bond investors increase their demand for longer-term bonds in response to a cut in short rates. Ozdagli and Wang (2019) show that although life insurance companies tilt their portfolios towards higher-yield bonds, the tilt is primarily driven by taking more duration risk rather than credit risk. Similarly, Chakraborty and MacKinlay (2020) also show that insurance companies reach for yield by taking more duration risk and credit risk. This paper extends their findings by documenting that mutual funds also tend to reach for yield via duration risk rather than credit risk. In addition, Van Binsbergen and Schwert (2021) show that the majority of returns earned by corporate bonds from 1997 to 2020 is due to falling interest rates rather than credit and liquidity risk premia.

Furthermore, our paper is related to papers that document heterogeneous responses between investment-grade bonds and high-yield bonds to monetary policy shocks. Ottonello and Winberry (2020) study the role of financial frictions and firm heterogeneity in determining the investment channel of monetary policy, they find that these firms with low default risk are much more responsive to monetary policy shocks. Our bond results are parallel to theirs, as we also find that these investment-grade funds which consist of low-default-risk bonds are much more responsive to monetary policy shocks than these high-yield bond funds which face larger default risk. This also echoes results in Guo, Kontonikas, and Maio (2020) who find that the interest rate channel is the dominant channel for high-rating bonds. In a different exercise, Acharya, Amihud, and Bharath (2013) also document heterogeneous responses between investment-grade bonds and speculative-grade bonds to liquidity shocks. Knowing these different responses between investment-grade and high-yield funds are important, for example, Chernenko and Sunderam (2012) show that the market segmentation between investment-grade and high-yield firms has consequences on firms' investment.

Finally, our paper is related to the literature on corporate mutual fund flows. Why do we care about these mutual fund flows? Ben-Rephael, Choi, and Goldstein (2021) show bond mutual fund flow is an early indicator of credit booms. Zhu (2021) shows bond mutual fund flows affect firms' capital supply. Furthermore, bond mutual fund flows have implications on the fragility of the corporate bond market and financial stability (Chen, Goldstein, and Jiang, 2010; Goldstein, Jiang, and Ng, 2017; Choi, Hoseinzade, Shin, and Tehranian, 2020). Fund flows also help predict fund performance (Chen and Qin, 2017).

3 Data

This paper uses both aggregate time series data of corporate bond mutual fund flows and fund-level flow panel data. The aggregate mutual fund flows data is collected from the Investment Company Institute (ICI), and the sample is monthly time series data expressed in billions of U.S. dollars from January 2016 to March 2022.

Figure 1 shows the time series of investment-grade and high-yield bond fund flows from

January 2016 to March 2022. There are large outflows from both mutual funds during the outbreak of 2020 Covid. Interestingly, the outflows from investment-grade bond funds are much larger than high-yield bond funds. As the figure shows, in March 2020, the outflows from investment-grade funds are around $90 billion, and there are around $20 billion in outflows from high-yield bond funds. This can be explained by mutual fund liquidity transformation (Ma, Xiao, and Zeng, 2022), where bond funds follow a pecking order of liquidation by selling their most liquid assets (e.g., investment-grade bonds) before more-illiquid ones (e.g., high-yield bonds).

However, after a series of the Fed's emergency responses, for example, the direct purchase of high-quality corporate bonds, both funds regained inflows. The rebound is especially dramatic for investment-grade funds, which keep attracting inflows. The trend reversed until the end of 2021 when the market expects the Fed is going to raise interest rates in the near future. Noticeably, during the 2022 monetary policy tightening, investment-grade bond funds also respond much more strongly to rising interest rates compared to high-yield bond funds.

The fund-level mutual fund flows data is collected from the CRSP Survivorship-Bias-Free Mutual Fund Database. The sample period we consider is from September 2000 to June 2020. The data contains information on fund returns, total net assets (TNA), expense ratio, turnover ratio, weighted average maturity, distribution yield and other fund characteristics. Our corporate bond mutual fund sample includes both investment-grade funds and high-yield funds, where the classification is based on each fund's Lipper objective code[2]. We do not include money market funds, municipal bonds, index funds and ETFs. We also drop those funds with a total net asset value (TNA) of less than 5 million U.S. dollars and funds with plenty of null values in TNA.

In addition, we collect monthly fund return data from the CRSP Survivorship-Bias-Free Mutual Fund Database. We collect monthly Fama-French three factors data from the data

[2]Investment-grade funds include those with Lipper's code equals A, BBB, IID, SII, SID, and USO. High-yield funds include those with Lipper's code equals HY, GHY and SHY.

library of Kenneth R. French. Other macroeconomic variables are from the Federal Reserve Bank of St. Louis (FRED), including the effective federal funds rate, industrial production, the CPI index, corporate bond yields, and corporate bond yield spreads.

Finally, we obtain the GZ credit spread data from Gilchrist and Zakrajšek (2012), and the DFL corporate bond liquidity data from Dick-Nielsen et al. (2012). Figure 2 plots the time series of the DFL liquidity index along with the GZ credit spread from July 2002 to June 2020. The two lines are parallel to each other, which indicates that the bond market liquidity index is highly correlated with overall market conditions. The higher value of the DFL index, the more illiquid the market is. During the 2008 financial crisis and the 2020 Covid outbreak, both GZ spread and the DFL index rose sharply.

The monetary policy shocks (MPS) and central bank information shocks (CBI) are obtained from Jarociński and Karadi (2020).

4 Evidence from time series mutual fund flows

In this section, we estimate the impulse responses of mutual fund flows to an expansionary monetary policy shock. We identify the monetary policy shock with sign-restricted vector autoregression (VAR)[3]. The identified monetary policy shock will be exogenous with respect to the endogenous variables in our VAR systems and uncorrelated with other exogenous shocks, thus we can estimate the causal effects of monetary policy on our interested variables.

[3] We do not choose to identify the monetary policy shocks with the standard Cholesky scheme, as Gertler and Karadi (2015) showed these conventional timing restrictions used in Cholesky identification cases do not work well in circumstances where financial variables are present in VARs.

4.1 Empirical models

We identify an expansionary monetary policy shock using a VAR with sign restrictions (Uhlig, 2005, 2017). The structural VAR (SVAR) is given by

$$A_0 y_t = c + A_1 y_{t-1} + ... + A_p y_{t-p} + v_t \tag{1}$$

where y_t is an $n \times 1$ vector of endogenous variables at time $t = 1, ..., T$, $A_i, i = 0, ..., p$, is an $n \times n$ coefficient matrix, p is the lag length. v_t is an $n \times 1$ vector of exogenous structural shocks, without loss of generality, assuming v_t with mean zero and variance-covariance matrix $E[v_t v_t'] = I_n$, c is an $n \times 1$ vector of intercepts.

The corresponding reduced-form VAR representation is

$$y_t = c + B_1 y_{t-1} + ... + B_p y_{t-p} + u_t \tag{2}$$

where $B_i = {A_0}^{-1} A_i, i = 1, ..., p$ and $u_t = {A_0}^{-1} v_t$. The covariance matrix of the reduced-form error u_t is

$$\Sigma = E[u_t u_t'] = {A_0}^{-1} E[v_t v_t'] {A_0}^{-1'} = {A_0}^{-1} {A_0}^{-1'} \tag{3}$$

In our VARs, the endogenous variable vector y_t includes the following six variables: the federal funds rate (FFR), the log difference of industrial production, the log difference of consumer price indexes (CPI), the credit spread measured by the difference between Moody's Seasoned Baa Corporate Bond Yield and Moody's Seasoned Aaa Corporate Bond Yield, the investment-grade bond mutual fund flows, the high-yield bond mutual fund flows.

The reduced-form VAR is estimated by using a Bayesian method with Normal-Wishart prior. The model is set with three lags ($p = 3$) according to the Bayesian Information Criterion.

4.2 Sign restrictions

Identification is achieved by imposing restrictions on ${A_0}^{-1}$. Based on the relationship between the residual u_t and the structural shock v_t, $u_t = {A_0}^{-1} v_t$, we then impose the following sign restrictions to identify the monetary policy shock

$$\begin{pmatrix} u_t^{FFR} \\ u_t^{ip} \\ u_t^{cpi} \\ u_t^{cs} \\ u_t^{ig} \\ u_t^{hy} \end{pmatrix} = \underbrace{\begin{pmatrix} - & 0 & 0 & 0 & 0 & 0 \\ + & 0 & 0 & 0 & 0 & 0 \\ + & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}}_{{A_0}^{-1}} \begin{pmatrix} v_t^{mp} \\ v_t^{ip} \\ v_t^{cpi} \\ v_t^{cs} \\ v_t^{ig} \\ v_t^{hy} \end{pmatrix} \tag{4}$$

where "−" represents negative restrictions, "+" represents positive restrictions, and "0" represents no restrictions, the first column of ${A_0}^{-1}$ corresponds to sign restrictions to identify the monetary policy shock. Equation 4 shows the identification is based on the assumption that an expansionary monetary policy shock is associated with a decrease in the federal funds rate, an increase in industrial production growth, and an increase in CPI growth. There are no restrictions on credit spread. In addition, since we are interested in the responses of investment-grade bond fund flows and high-yield bond fund flows, we do not impose sign restrictions on these two variables. Finally, following Uhlig (2005), we impose the same sign restrictions for five horizons.

4.3 Results

Figure 3 shows the impulse responses to an expansionary monetary policy shock identified with sign-restricted VAR. The figure shows the median as well as the 16% and the 84% quantiles for the sample of impulse responses. The sample is from January 2016 to March 2022. The X-axis is the response time in months.

By identification assumption, on impact, the expansionary monetary policy shock leads to a decrease in FFR, an increase in industrial production, and CPI. Figure 3 indeed shows that the responses of these variables satisfy these sign restrictions, and the sign restrictions last at least five months. Moreover, we find that in response to a one standard deviation expansionary monetary policy shock, the credit spread decreases, which reflects economic conditions are getting better under a monetary easing environment.

We are particularly interested in the responses of bond fund flows. We find that in response to an expansionary monetary policy shock, investment-grade funds receive large inflows. Contemporaneously, a one standard deviation expansionary monetary policy shock leads to around two billion dollars of inflows to investment-grade bond funds. Moreover, the inflows reach their peak in the second month after the shock, where the inflows are over three billion dollars. The inflows remain statistically significant for five months. However, the responses of high-yield bond fund flows are wandering around zero, and all confidence intervals include zero, which suggests that high-yield bond funds do not receive inflows in response to an expansionary monetary policy shock.

Our results echo Ottonello and Winberry (2020), who also document that these high-quality firms with low default risk are more responsive to monetary policy shocks, and Guo et al. (2020), who find that the interest rate channel is the dominant channel for high-rating bonds. The different responses between investment-grade bond and high-yield bond investors are likely driven by the fact that investment-grade bonds are primarily exposed to interest rate risk. High-yield bonds face little interest rate risk but are much more exposed to default and credit spread risk. Therefore, investment-grade fund flows should be more sensitive to the change in interest rates. We further verify the differences in interest rate sensitivity between investment-grade funds and high-yield funds in the next section with panel data.

5 Evidence from fund-level flows

In this section, we complement the time series fund flows data with fund-level panel data. The panel data sample is in quarterly frequency, runs from September 2000 to June 2020, and gives details of individual funds' characteristics, such as fund returns, fund maturity, distribution yields, etc.

We first re-examine the relationship between fund flows and changes in FFR with additional control variables of fund characteristics. The previous VAR results show that in response to an expansionary monetary policy shock, investment-grade funds receive inflows, while flows of high-yield funds are not responsive. What's the mechanism behind these fund flow patterns? The different responses between investment-grade funds and high-yield funds should be related to their distinct interest rate sensitivities, thereby we also examine the interest rate sensitivity of investment-grade and high-yield funds, respectively.

In addition, we study how investors in each bond asset class respond to the Fed's lower interest rate policy. As lower interest rates lead to lower bond yields, therefore, in order to regain these lost yields, will bond investors take more credit risk or duration risk?

5.1 Summary statistics

Following the prior literature on fund flows, we first calculate each individual fund's flow using equation (5):

$$Flow_{i,t} = \frac{TNA_{i,t} - TNA_{i,t-1} \times (1 + R_{i,t})}{TNA_{i,t-1}}, \tag{5}$$

where $TNA_{i,t}$ is fund i's total net asset in millions of U.S. dollars at time t, $R_{i,t}$ is the quarterly fund return.

Table 1 presents the summary statistics for both investment-grade funds and high-yield funds, and both samples are quarterly data from September 2000 to June 2020. On average, both investment-grade (IG) funds and high-yield (HY) funds gain inflows during this sample period. The average IG fund inflow is 1.75 percent, and the average HY fund inflow is 2.25

percent. As for the returns, the average quarterly return of IG funds is 0.26 percent and the median is 0.31 percent, and the average return of HY funds is -0.24 percent and the median is 0.51 percent. In addition, the average total net asset (TNA) of IG funds is $505.60 million, and the average total net asset (TNA) of HY funds is $931.36 million. The median is $176.70 million and $259.00 million, respectively. The variable size is derived from $log(TNA)$.

The quarterly IG fund return volatility is 0.98 percent, and the return volatility of HY funds is 1.47 percent. On average, IG funds have a lower expense ratio than HY funds. The average expense ratio for IG funds is 0.97 percent, and it's 1.12 percent for HY funds. By contrast, the turnover ratio for IG funds is greater than for HY funds. The mean turnover ratio for IG funds is 132.74 percent, and it is 71.11 percent for HY funds. Both funds have similar percentages of institutional funds. There are 27 percent institutional funds in IG funds, and 25 percent in HY funds.

Overall, IG funds have a longer maturity than HY funds. Specifically, the weighted average maturity for IG funds is 13.10 years, and the weighted average maturity for HY funds is much shorter, it's 6.87 years. Moreover, the median maturity for both funds is 12.30 and 6.60 years, respectively. The average distribution yield [4] for IG funds is 1.48 percent, and the average distribution yield for HY funds is higher, which is 2.37 percent. The average cash holdings of IG funds are 1.5 percent, and the average cash holdings for HY funds are 3.53 percent.

5.2 Lower interest rates and fund flows

In this section, we study the relationship between fund flows and changes in interest rates for investment-grade funds and high-yield funds, respectively. Specifically, we examine whether a reduction in FFR is associated with inflows of investment-grade bond funds.

We begin by estimating the relationships between FFR changes and fund flows with the

[4] Distribution yield is calculated as the ratio of income distributions and net asset value at the end of the period.

following panel regression:

$$Flow_{i,t+1} = \beta.\triangle FFR_t + \gamma.Z_{i,t} + \epsilon_{i,t+1}, \tag{6}$$

where $Z_{i,t}$ represents control variables, including fund returns, return volatility, fund size ($log(TNA)$), expense ratio, turnover ratio, institution dummy variable, maturity, and distribution yields. $\triangle FFR_t$ is the quarterly changes of the federal fund rate from time $t-1$ to time t. $\epsilon_{i,t+1}$ is the error term.

The coefficient β shows the impact of change in FFR on fund flows. According to previous VAR results of aggregated fund flows, we expect β to be negative for investment-grade funds, which means when the Fed decreases the FFR, there are inflows to investment-grade funds. In addition, we also test the robustness of our results by including the credit spread control variable [5].

Table 2 presents the estimation results. To address issues of residual serial dependence for a fund over time and correlated residuals across different funds, we cluster the standard errors by both the fund and quarter levels. In all regressions, we include fund-fixed effects. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds.

For the investment-grade funds, the estimated coefficients on $\triangle FFR$ are negative and statistically significant. For example, column (1) shows the estimated coefficient is -1.502 and statistically significant at the 5% level, which indicates that a one percentage point decrease in the FFR corresponds to a 1.502 percent increase in investment-grade fund inflows. In contrast, the estimated coefficients on $\triangle FFR$ are not statistically significant in all cases for high-yield bond funds. Therefore, consistent with our VAR results, we find that in response to the Fed's lower interest rate policy, investment-grade funds receive inflows, and high-yield funds are not responsive.

[5] As before, credit spread is measured by the difference between Moody's Seasoned Baa Corporate Bond Yield and Moody's Seasoned Aaa Corporate Bond Yield.

However, there may be concerns about the endogeneity of changes in FFR as a monetary policy measure. That is, $\triangle FFR$ is correlated with other macroeconomic and financial variables, which is predictable by the public prior to the Fed announcement. In order to alleviate these concerns, we additionally test the relationship between fund flows and interest rates with the monetary policy shocks constructed by Jarociński and Karadi (2020), henceforth referred to as JK MPS. The monetary policy shocks are identified through sign restrictions on high-frequency co-movement of interest rates and stock prices in a narrow window around the Fed announcement and separated from contemporaneous information shocks. Therefore, the identified monetary policy shocks should be exogenous.

Table 3 presents the estimated results of the relationship between fund flows and JK monetary policy shocks. The estimated coefficient of MPS in column (2) for investment-grade funds is -5.841 and is statistically significant at the 5% level. The result suggests that expansionary monetary policy shocks lead to inflows of investment-grade bond funds. The estimated coefficients of MPS are not statistically significant in columns (3) and (4) for high-yield bond funds. Overall, in line with the estimated results in Table 2 of $\triangle FFR$, we find that in response to lower interest rates, bond investors buy more investment-grade funds, while high-yield bond funds do not gain inflows.

5.3 Interest rate sensitivity

Why do investment-grade funds and high-yield funds respond so differently to changes in interest rates? In this section, we answer the question by examining their interest rate sensitivity. Our estimation is based on Fama and French (1993) with the five factors: the excess stock market return factor (MktRF), the size factor (SMB), the book-to-market factor (HML), and the additional two common factors for bonds, the term spread factor (TERM) and the default spread factor (DEF). In our regressions, we substitute the TERM factor with the negative change of $\triangle FFR$ so that the estimated coefficient represents bond duration. We calculate the DEF factor with the yield spread between ICE BofA US high yield index option-adjusted spread and ICE BofA BBB US corporate index option-adjusted spread. Both data are obtained from the FRED. Particularly, we estimate the following equation

$$R_{i,t} = \alpha + \beta_f(-\triangle FFR_t) + \beta_d DEF_t + \beta_m MktRF_t + \beta_s SMB_t + \beta_h HML_t + \epsilon_{i,t}, \quad (7)$$

where $R_{i,t}$ is the excess return between the fund return and the one-month T-bill risk-free rate.

We estimate the model with two samples, one is the full-sample, which is from September 2000 to June 2020, and the other one is the sub-sample, which excludes the zero lower bound (ZLB) periods, where the federal funds rate stays at the range between 0 and 0.25 percent. Table 4 presents the estimation results, and the coefficient of $-\triangle FFR$ captures the interest rate sensitivity. Columns (1)-(4) show the estimated results for investment-grade funds, and columns (5)-(8) are the estimated results for high-yield funds. Columns (1), (2), (5), and (6) are the results of the full sample, and columns (3), (4), (7), and (8) are the results of the sub-sample (without ZLB period). First, we notice all the estimated coefficients are statistically significant at the 1% level.

The estimated coefficients for $-\triangle FFR$ are 0.424 and 0.444 in columns (1) and (2) for investment-grade funds, and the corresponding coefficients for high-yield funds in columns (5), (6) are 0.143 and 0.169, both are smaller than the value in investment-grade funds. Similarly, the coefficients are 0.751 and 0.837 in columns (3) and (4) for investment-grade funds, and the corresponding coefficients for high-yield funds are 0.504 and 0.597 in columns (7) and (8). In both cases, the interest rate sensitivity of investment-grade bond funds is much higher than high-yield bond funds. This explains why we see large inflows to investment-grade funds, while high-yield funds are not responsive in response to the change of FFR.

5.4 Credit risk and duration risk effects

In this section, we explore investors' investment behavior inside investment-grade bond funds and high-yield bond funds. Specifically, we investigate the effects of credit risk and duration risk on investors' responses to the Fed's lower interest rate policy. As is well known, lower interest rates lead to higher bond prices, and hence, bond yields decrease. Consequently, investors have to regain these lost yields through additional risk exposures.

Investors can obtain higher yields by investing more in lower-rated bonds or buying longer-maturity bonds within a rating category. The former involves taking more credit risk, and the latter is taking more duration risk. The divergent flow response patterns between investment-grade and high-yield bond funds are likely linked to their distinct risk exposures.

Formally, we test the mechanism behind these flow patterns through the hypothesis:

Hypothesis. Investment-grade bonds are primarily exposed to interest rate risk. High-yield bonds face little interest rate risk but are much more exposed to default and credit spread risk.

We test this hypothesis by estimating the effects of credit risk and duration risk on bond investments through the following two panel regressions

$$\begin{aligned} Flow_{i,t+1} = \gamma_1 \triangle FFR_t + \gamma_2 \triangle CreditSpread_t + \gamma_3 \triangle FFR_t \times \triangle CreditSpread_t \\ + \gamma_4 Z_{i,t}, + \epsilon_{i,t+1}, \end{aligned} \tag{8}$$

$$Flow_{i,t+1} = \gamma_1 Maturity_{i,t} + \gamma_2 \triangle FFR_t \times Maturity_{i,t} + \gamma_3 Z_{i,t} + \epsilon_{i,t+1} \tag{9}$$

where the notations here are with the same definitions as those in equation (6). Moreover, equation (8) is estimated with fund-fixed effects, while equation (9) is estimated with both fund and quarter-fixed effects.

The coefficient of the interaction term $\triangle FFR \times \triangle CreditSpread$ captures the effects of credit risk on fund flows with the change of FFR. As we have already shown in Table 2 that when the interest rate turns lower, there are inflows to investment-grade funds. Therefore, if the estimated interaction coefficient $\triangle FFR \times \triangle CreditSpread$ is positive, this suggests that when the Fed reduces the FFR, the higher the credit spread, the fewer inflows to the funds, that is, credit spread has negative effects on fund inflows.

More importantly, if our hypothesis is true, we should expect the magnitude of the estimated coefficients $\triangle FFR \times \triangle CreditSpread$ to be larger for high-yield bond funds than investment-grade bond funds. In addition, since longer maturity bonds face more duration risk. If in response to a lower interest rate, bond investors are indeed taking more duration risk, we should expect the coefficient of the interaction term $\triangle FFR \times Maturity$ to be negative, which means a lower interest rate leads to more inflows to longer maturity funds. In terms of statistical significance and magnitude, the estimates should be much more significant for investment-grade funds than high-yield funds.

Table 5 shows the estimation results. First, for investment-grade funds, as shown in column (1), the estimated coefficient of the interaction term $\triangle FFR \times \triangle CreditSpread$ is 3.104, and it's statistically significant at the 1 percent level. In column (4) of the high-yield bond funds, the corresponding coefficient is 3.199, and it is statistically significant at the 1 percent level. Both results suggest that credit risk indeed has negative effects on fund flows, the higher the credit spread, the fewer inflows to the fund. This suggests that investors are not willing to take more credit risk in order to gain a higher yield. Moreover, as evidenced by the magnitude, it seems that the effects of credit risk on high-yield bond funds are greater than on investment-grade bond funds.

Second, regarding the effects of duration risk, as shown in column (2) for investment-grade funds, the estimated coefficient of the interaction term $\triangle FFR \times Maturity$ is -0.178 and statistically significant at the 5 percent level. The result suggests that when the Fed reduces the FFR, there are more inflows to these longer-maturity investment-grade bond funds, namely, investors tend to take more duration risk through buying longer-maturity funds. For high-yield funds, the coefficients on the interaction term $\triangle FFR \times Maturity$ are not statistically significant in column (5), which suggests that investors in high-yield bond funds are not responding to a lower interest rate by taking more duration risk.

In addition, columns (3) and (6) show the effects of credit risk and duration risk on fund flows by including both interaction terms $FFR \times \triangle CreditSpread$ and $FFR \times Maturity$ in our regressions. The conclusion remains the same, that is, credit risk has negative effects on fund flows, and greater credit spreads lead to fewer inflows. Moreover, there are more inflows to longer-maturity investment-grade bond funds as FFR becomes lower.

Next, we also test the credit risk and duration risk effects with JK monetary policy shocks. Table 6 presents the estimated results. First, for the effect of credit risk, the estimated coefficients of $MPS \times \triangle CreditSpread$ are 8.276 and 8.249 in columns (4) and (6) for high-yield funds. Moreover, both estimates are statistically significant at the 5% level. In line with our findings in Table 5, these statistically significant positive coefficients suggest that higher credit risk has negative effects on high-yield fund flows, that is, higher credit risk causes fewer inflows. However, the corresponding coefficients in columns (1) and (3) are not statistically significant for investment-grade bond funds. The result suggests that credit risk has limited effects on investment-grade bond funds, which is consistent with our hypothesis.

In addition, if our hypothesis holds true, we should expect the interest rate risk effects to be much more significant for investment-grade bond funds. Indeed, the estimated coefficient of $MPS \times Maturity$ in column (2) is -1.391 and is statistically significant at the 5% level, which suggests that when interest rates become lower, there are more inflows to longer maturity investment-grade funds, that is, investors are willing to take more duration risk. By contrast, the corresponding coefficients of $MPS \times Maturity$ for high-yield bond funds are not statistically significant. This indicates duration risk plays an insignificant role in high-yield bond fund flows. The conclusion remains the same after we include both the interaction terms of $MPS \times \triangle CreditSpread$ and $MPS \times Maturity$.

In summary, we find that in response to a lower interest rate, while bond yields decline, investors are not willing to take more credit risk by buying lower-rated bonds. Instead, they are more willing to take higher duration risk by buying longer maturity bond funds.

6 Flights to safety and Fed information effects

In response to the Fed's lower interest rate policy, there are flows into these high-quality investment-grade funds. Since investment-grade bonds are much safer than high-yield bonds, some may argue that these fund flow patterns are driven by investors' flights to safety but not necessarily the Fed's interest rate policy. Flights to safety describe the phenomenon that investors increase their appetite for safe assets relative to risky assets, which tends to happen in periods of market stress.

In addition, there might be a concern that the flows are driven by the Fed's information effect but not necessarily the change of interest rates, where an easing monetary policy communicates that the state of the economy is weaker than the public had expected (Romer and Romer, 2000; Nakamura and Steinsson, 2018; Jarociński and Karadi, 2020). If so, investors may become pessimistic and buy more safe investment-grade bonds. Therefore, in this section, we additionally test whether the inflows to investment-grade funds are driven by flights to safety or Fed information effects.

Following Baele et al. (2020), we identify flight-to-safety periods with the Markov regime-switching models of Hamilton (1989). According to Beber et al. (2009), liquidity plays a dominant role in driving bond flows during market stress periods, therefore, we define flight-to-safety periods as the time when the estimated market illiquidity regime probability exceeds 90%. We use the DFL corporate bond liquidity index (Dick-Nielsen et al., 2012) to measure the market liquidity.

Table 7 shows the Markov regime-switching estimation results. There are two regimes in the model, with regime 0 being a highly illiquid state and regime 1 being a highly liquid state. The estimated mean value of the DFL liquidity measure in regime 0 is 1.598, and the mean value of the DFL liquidity measure in regime 1 is -1.064. The estimated transition probability from a current regime 0 to staying at regime 0 next is 0.931, and the estimated transition probability from a current regime 1 to regime 0 in the next period is 0.014.

Figure 4 plots the time series of the estimated probabilities of being in the highly illiquid state and highly liquid state from July 2002 to June 2020. We define flight-to-safety (FTS) periods as the time when the estimated market illiquidity regime probability exceeds 90%. As the figure shows, the FTS periods concentrate on three periods: a short period during 2002, a longer period during the 2008-2009 financial crisis, and a one-month period during the Covid-19 outbreak.

After identifying the FTS periods, we then test whether the FTS periods alter the relationship between fund flows and change of FFR by running the regression (6) with a sub-sample that excludes periods of flights to safety. If the results are indeed driven by flights to safety, we may see changes in the sign of the coefficient of $\triangle FFR$.

Table 8 shows the estimation results. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Columns (1) and (3) are the results of full sample. Columns (2) and (4) are the results of the sub-sample, which excludes the FTS periods.

The estimated coefficient of $\triangle FFR$ of the sub-sample is -1.799. Compared to the full-sample results, the sub-sample coefficient is still negative and statistically significant for investment-grade funds. The estimated coefficients for high-yield funds are not statistically significant. Both results are consistent with our previous findings that there are inflows to investment-grade funds in response to a lower interest rate and the high-yield funds are not responsive. That is, flights to safety do not alter the flow and change in the FFR relationship.

Next, we test whether the inflows to investment-grade bond funds are driven by Fed information effects. Specifically, we use the identified central bank information (CBI) shocks of Jarociński and Karadi (2020) to capture the Fed information effects. If the inflows are indeed driven by Fed information effects, we should expect the estimated coefficient of CBI to be negative and statistically significant.

Table 9 presents the comparison between monetary policy shock and information shock effects on fund flows. The estimated coefficient of CBI in column (2) for investment-grade funds is 0.317 but without statistical significance, which suggests that Fed information effects do not contribute to inflows of investment-grade bond funds. However, the estimated coefficient of CBI in column (4) for high-yield funds is statistically significant, and the value is 20.893. The result indicates that a negative information shock leads to outflows from high-yield bond funds. This should not be surprising given that the Fed's negative information shocks convey pessimistically economic outlook, investors are thus likely to pull money out of these risky high-yield bonds.

In summary, both results confirm that investment-grade bond fund flows are not driven by flights to safety or Fed information effects. Instead, the Fed's lower interest rate policy contributes to these inflows.

7 Fund flows and rising interest rates

In previous sections, we have shown the effects of lower interest rates on fund flows and the role of interest rate risk on bond investors' investment decisions. We find that lower interest rates lead to inflows of investment-grade bond funds, while high-yield bond fund flows are not responsive. Moreover, investors tend to buy longer maturity investment-grade bond funds in order to take advantage of lower interest rate risk.

These findings are of significance given that we have been in a low interest-rate environment in the past decade. However, the environment changed in early 2022 when the Fed began to raise the policy rate in order to fight inflation. By the end of 2022, the federal funds rate was increased to the 4.25-4.50 percent target range. Therefore, it also becomes highly relevant to study the effects of rising interest rates on bond investment.

With the change in interest rates, it changes the interest rate risk faced by investors. As the Fed raises interest rates, the bond price declines, which implies higher interest rate risk. As a result, it likely pushes investors to move away from long-term bond funds to short-term bond funds. In this section, we first examine the relationship between investment-grade bond fund flows and the rise of interest rates. In addition, we study the effects of maturity on this relationship. In response to higher interest rates, will there be inflows to short-term bond funds and outflows from longer-maturity bond funds? Furthermore, are the long-term fund outflows towards short-term fund inflows?

The mutual fund data used in this section is from the fourth quarter of 2020 to the fourth quarter of 2022, as we focus on the rising interest rates. All the variables are of the same definitions as before. Table 10 presents the estimation results of Regression (6) and Regression (9) with this new data. Column (1) shows the relationship between investment-grade fund flows and $\triangle FFR$, specifically, we are interested in the effects of an increase in FFR. The estimated coefficient of $\triangle FFR$ is -11.466, and it's statistically significant at the 1% level. The result suggests that a 1% increase in FFR leads to 11.466 % investment-grade bond fund outflows.

Column (2) shows the effects of bond maturity on this relationship. The estimated coefficient of $\triangle FFR \times Maturity$ is -0.770, and it's statistically significant at the 5% level. The result indicates that following a 1% increase in FFR, a one-year increase in the weighted average maturity leads to additional 0.770 % investment-grade fund outflows. That is, we find that the longer maturity of a fund, the more outflows. The estimation is based on fund and quarter fixed effects, and standard errors are double-clustered.

Columns (3) and (4) show the same estimation results of high-yield bond funds. Both the estimated coefficients of $\triangle FFR$ and $\triangle FFR \times Maturity$ are not statistically significant. The results confirm that interest rate risk does not play a significant role in high-yield bond funds.

Next, we shed light on the effects of rising interest rates on short-term investment-grade bond fund flows. Formally, we estimate the following equation:

$$Flow_{i,t+1} = \gamma_1 Short_{i,t} + \gamma_2 \triangle FFR_t \times Short_{i,t} + \gamma_3 Z_{i,t} + \epsilon_{i,t+1} \tag{10}$$

The new variable is $Short_{i,t}$, which is a dummy variable, and it is defined based on the weighted average maturity.

Table 11 presents the estimation results of Equation (10). Column (1) shows the effects of rising interest rates on these short-term investment-grade bond fund flows, whose weighted average maturity is less than 5 years. The estimated coefficient of $\triangle FFR \times Short$ is 6.303, and it's statistically significant at the 10 % level. The result suggests that following a one percent increase in FFR, these investment-grade funds with a weighted average maturity of fewer than 5 years receive 6.303 % more inflows relative to these funds with a maturity greater or equal to 5 years.

Column (2) shows the same effects except that the *Short* variable now is defined as these funds with a maturity of fewer than 10 years. The estimated coefficient of $\triangle FFR \times Short$ is 7.496, and it's statistically significant at the 5 % level. The result suggests that following a one percent increase in FFR, these investment-grade funds with a weighted average maturity of fewer than 10 years receive 7.496 % more inflows relative to these funds with a maturity greater or equal to 10 years. Namely, we find that in response to higher interest rates, short-term investment-grade bond funds gain inflows relative to long-term bond funds. Both results are estimated with two-way fixed effects, and standard errors are double-clustered.

The previous results demonstrate that when the Fed hikes the policy rate, there are outflows from long-term investment-grade bond funds, furthermore, short-term funds gain inflows relative to long-term funds. We formally estimate the contemporaneous relationship between short-term fund flows and long-term fund outflows with the equation

$$Shorttermflows_{i,t} = \beta.longtermflows_{i,t} + \epsilon_{i,t} \tag{11}$$

We classify whether a fund is long-term or short-term based on the weighted average maturity (WAM). The median of WAM is 11.4 years in our sample. Thus, if the maturity is less than 11.4, it's a short-term fund, otherwise, it's long-term. Table 12 shows the estimation results of the response of short-term fund flows to long-term fund outflows with three different samples. Column (1) shows the results with a full sample, which is from Q4 of 2020 to Q4 of 2022. The sample has a total of 7,477 observations, the estimated coefficient of $longtermflows$ is 0.003, and it's not statistically significant. The result suggests that in the full sample, there is no contemporaneous relationship between short-term fund flows and long-term fund flows.

Column (2) shows the results with a subsample, the sample is from Q4 of 2020 to Q4 of 2021 right before the Fed's interest rates hike in 2022, and there are 4,170 observations. The estimated coefficient of $longtermflows$ is -0.125, and it's not statistically significant. That is, we also find no contemporaneous relationship between these two variables in this subsample.

Finally, column (3) shows the results of the rising interest rates period, which is from Q1 of 2022 to Q4 of 2022 with a total of 3,307 observations. The estimated coefficient is -0.014, and it's statistically significant at the 1 % level. Thus, we find a negative relationship between short-term bond fund flows and long-term flows, a 1 % long-term fund outflow leads to a contemporaneous 0.014 % short-term fund inflow. The results of columns (1) and (2) are control groups relative to column (3), since we focus on the effects of rising interest rates. In our data sample, 2022 is the only year with a continuous increase in FFR. Our results confirm that following the Fed's interest rates hike, investors move away from long-term bond funds and toward short-term bond funds. All three samples are estimated with two-way fixed effects, and the standard errors are double-clustered.

8 Robustness checks

In this section, we provide additional evidence of our results through robustness tests. First, regarding the time-series results, we do the robustness check by adding government bond fund flows to our structural vector autoregressions. Second, instead of using the short-term effective federal funds rate, we test our panel regression results with a long-term 10-year treasury yield.

Some may wonder whether the inflows to these safe investment-grade bond funds are coming from government bond fund outflows. Figure 5 shows impulse responses of investment-grade, high-yield, and government bond fund flows to an expansionary monetary policy shock. Consistent with previous results in Figure 3, we find that in response to an expansionary monetary policy shock, investment-grade funds receive large inflows on impact, while high-yield fund flows are not responsive. The new finding is that government bond funds also gain inflows. In general, government bonds have a long duration, therefore, inflows to these government bond funds indicate bond investors indeed tend to take duration risk when interest rates decrease. The result is consistent with our previous finding regarding the duration effects on investment-grade funds.

Table 13 shows the robustness test of the relationship between fund flows and change of 10-year long-term interest rate GS10. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Columns (1), and (3) are the results of the full sample, and columns (2) and (4) are the results of the sub-sample, which excludes the flight-to-safety periods. For investment-grade funds, the coefficient of $\triangle GS10$ in column (1) is -2.988, and it's statistically significant at the 5 percent level. The coefficient $\triangle GS10$ is -2.802 and statistically significant in column (2). Both results suggest that when the interest rate becomes lower, there are inflows to investment-grade funds. In contrast, the coefficients of $\triangle GS10$ are not statistically significant for high-yield bond funds, which suggests high-yield funds are not responsive to the change in interest rates. Therefore, the relationship between fund flows and change in interest rates are robust to different measures of interest rates.

Table 14 shows the estimation of interest rate sensitivity with the 10-year treasury yield. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. For investment-grade funds, the coefficient of $-\triangle GS10$ in column (1) with three factors is 0.25 and statistically significant at the 1 percent level, and the coefficient is 0.292 and statistically significant at the 1 percent level in column (2) with five factors. The coefficients of $-\triangle GS10$ are 0.049 and 0.05 in columns (3) and (4) for high-yield funds. Both are much smaller than the coefficients for investment-grade funds, which suggests the interest rate sensitivity of high-yield funds is lower than investment-grade funds. Therefore, tests for interest rate sensitivity are also robust to different measures of interest rates.

Next, we do robustness tests for the effects of credit risk and maturity on fund flows. Table 15 shows the estimation results. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. The coefficient of $\triangle GS10 \times \triangle CreditSpread$ in column (1) for investment-grade funds is 0.490, and it is not statistically significant. The corresponding coefficient for high-yield funds in column (4) is 3.341 and it is statistically significant at the 1 percent level. The results remain the same as in columns (3) and (6). Therefore, in line with our previous findings, we conclude that credit risk plays a very significant effect on high-yield bond funds while having limited effects on investment-grade bond funds.

As shown in column (2), the coefficient of $\triangle GS10 \times Maturity$ is -0.368 and statistically significant at the 5 percent level, which suggests that investors are buying longer maturity investment-grade funds in response to a lower GS10 interest rate. The corresponding coefficient for high-yield funds in column (4) is not statistically significant. Therefore, we find that in response to a lower 10-year treasury yield, investors are still not willing to take credit risk, but are willing to take more duration risk by buying longer-maturity bond funds.

9 Conclusion

In response to the Fed's lower interest rate policy, do investors in corporate bond mutual funds reach for yield? We find bond investors are not necessarily reaching for yield. Instead, we document that following an expansionary monetary policy shock, investment-grade funds receive inflows, while high-yield funds are not responsive. These flow patterns can not be explained by investors' incentives to reach for yield. We explore the mechanism behind this, and the key lies in their different interest rate risk exposures.

Investment-grade funds have a longer duration than high-yield funds and are primarily exposed to interest rate risk. While high-yield funds face little interest rate risk but are much more exposed to default and credit spread risk. Therefore, high-yield bond funds are not as sensitive to the change in interest rates as investment-grade bond funds. When interest rate becomes lower, interest rate risk also declines, which makes investment-grade bond funds more attractive, and thus gain inflows. We also verify that the results are not driven by flights to safety and Fed information effects.

In addition, we explore investors' investment behavior inside investment-grade bond funds and high-yield bond funds. It is well-known that bond investors usually have yield targets when buying bonds. Thus, as a lower interest rate leads to a decline in bond yields, investors have to regain these lost yields through more risk exposures in other places. We find that investors are not willing to take more credit risk by buying lower-rated bonds in order to regain these lost yields. Instead, they are more willing to take higher duration risk by buying longer maturity bond funds.

Furthermore, we study the effects of rising interest rates during 2022 on investment-grade bond fund flows. We find that following the Fed's interest rate hikes, there are outflows from long-term investment-grade bond funds. In contrast, these short-term bond funds receive inflows relative to long-term funds. During periods of monetary policy tightening, interest rate risk increases, which pushes investors away from long-term bond funds and towards short-term bond funds.

Finally, our results provide empirical evidence on the interest rate exposure of monetary policy transmission, which should have policy implications in terms of the effects on bond risk premia. When investors take more duration risk in response to an easing monetary policy, this drives up the demand for longer-term bonds, and hence, lowers the bond term premia.

The results also have implications on the cost of firms' capital supply, higher demand for longer-maturity bonds may push firms to issue longer-maturity debt at a higher cost.

References

Acharya, V. V., Amihud, Y., Bharath, S. T., 2013. Liquidity risk of corporate bond returns: conditional approach. Journal of Financial Economics 110, 358–386.

Auclert, A., 2019. Monetary policy and the redistribution channel. American Economic Review 109, 2333–67.

Baele, L., Bekaert, G., Inghelbrecht, K., Wei, M., 2020. Flights to safety. The Review of Financial Studies 33, 689–746.

Beber, A., Brandt, M. W., Kavajecz, K. A., 2009. Flight-to-quality or flight-to-liquidity? evidence from the euro-area bond market. The Review of Financial Studies 22, 925–957.

Becker, B., Ivashina, V., 2015. Reaching for yield in the bond market. The Journal of Finance 70, 1863–1902.

Begenau, J., Piazzesi, M., Schneider, M., 2015. Banks' risk exposures. Tech. rep., National Bureau of Economic Research.

Ben-Rephael, A., Choi, J., Goldstein, I., 2021. Mutual fund flows and fluctuations in credit and business cycles. Journal of Financial Economics 139, 84–108.

Campbell, J. Y., Sigalov, R., 2022. Portfolio choice with sustainable spending: A model of reaching for yield. Journal of Financial Economics 143, 188–206.

Chakraborty, I., MacKinlay, A., 2020. The effects of financing frictions in investment-grade debt markets. University of Miami Business School Research Paper .

Chen, Q., Goldstein, I., Jiang, W., 2010. Payoff complementarities and financial fragility: Evidence from mutual fund outflows. Journal of Financial Economics 97, 239–262.

Chen, Y., Qin, N., 2017. The behavior of investor flows in corporate bond mutual funds. Management Science 63, 1365–1381.

Chernenko, S., Sunderam, A., 2012. The real consequences of market segmentation. The Review of Financial Studies 25, 2041–2069.

Choi, J., Hoseinzade, S., Shin, S. S., Tehranian, H., 2020. Corporate bond mutual funds and asset fire sales. Journal of Financial Economics 138, 432–457.

Choi, J., Kronlund, M., 2017. Reaching for yield in corporate bond mutual funds. The Review of Financial Studies 31, 1930–1965.

Daniel, K., Garlappi, L., Xiao, K., 2021. Monetary policy and reaching for income. The Journal of Finance 76, 1145–1193.

Di Maggio, M., Kacperczyk, M., 2017. The unintended consequences of the zero lower bound policy. Journal of Financial Economics 123, 59–80.

Dick-Nielsen, J., Feldhütter, P., Lando, D., 2012. Corporate bond liquidity before and after the onset of the subprime crisis. Journal of Financial Economics 103, 471–492.

Drechsler, I., Savov, A., Schnabl, P., 2021. Banking on deposits: Maturity transformation without interest rate risk. The Journal of Finance 76, 1091–1143.

Fama, E. F., French, K. R., 1993. Common risk factors in the returns on stocks and bonds. Journal of Financial Economics 33, 3–56.

Faulkender, M., 2005. Hedging or market timing? selecting the interest rate exposure of corporate debt. The Journal of Finance 60, 931–962.

Gertler, M., Karadi, P., 2015. Monetary policy surprises, credit costs, and economic activity. American Economic Journal: Macroeconomics 7, 44–76.

Gilchrist, S., Zakrajšek, E., 2012. Credit spreads and business cycle fluctuations. American Economic Review 102, 1692–1720.

Goldstein, I., Jiang, H., Ng, D. T., 2017. Investor flows and fragility in corporate bond funds. Journal of Financial Economics 126, 592–613.

Gomez, M., Landier, A., Sraer, D., Thesmar, D., 2021. Banks' exposure to interest rate risk and the transmission of monetary policy. Journal of Monetary Economics 117, 543–570.

Guo, H., Kontonikas, A., Maio, P., 2020. Monetary policy and corporate bond returns. The Review of Asset Pricing Studies 10, 441–489.

Hamilton, J., 1989. A new approach to the economic analysis of nonstationary time series and the business cycle. Econometrica 57, 357–84.

Hanson, S. G., Stein, J. C., 2015. Monetary policy and long-term real rates. Journal of Financial Economics 115, 429–448.

Hau, H., Lai, S., 2016. Asset allocation and monetary policy: Evidence from the eurozone. Journal of Financial Economics 120, 309–329.

Hoffmann, P., Langfield, S., Pierobon, F., Vuillemey, G., 2019. Who bears interest rate risk? The Review of Financial Studies 32, 2921–2954.

Hu, G. X., Pan, J., Wang, J., Zhu, H., 2022. Premium for heightened uncertainty: Explaining pre-announcement market returns. Journal of Financial Economics 145, 909–936.

Huang, J.-Z., Huang, M., 2012. How much of the corporate-treasury yield spread is due to credit risk? The Review of Asset Pricing Studies 2, 153–202.

Jarociński, M., Karadi, P., 2020. Deconstructing monetary policy surprises—the role of information shocks. American Economic Journal: Macroeconomics 12, 1–43.

Lian, C., Ma, Y., Wang, C., 2019. Low interest rates and risk-taking: Evidence from individual investment decisions. The Review of Financial Studies 32, 2107–2148.

Ma, Y., Xiao, K., Zeng, Y., 2022. Mutual fund liquidity transformation and reverse flight to liquidity. The Review of Financial Studies 35, 4674–4711.

Nakamura, E., Steinsson, J., 2018. High-frequency identification of monetary non-neutrality: the information effect. The Quarterly Journal of Economics 133, 1283–1330.

Ottonello, P., Winberry, T., 2020. Financial heterogeneity and the investment channel of monetary policy. Econometrica 88, 2473–2502.

Ozdagli, A. K., Wang, Z. K., 2019. Interest rates and insurance company investment behavior. Available at SSRN 3479663 .

Rajan, R. G., 2006. Has finance made the world riskier? European Financial Management 12, 499–533.

Romer, C. D., Romer, D. H., 2000. Federal reserve information and the behavior of interest rates. American Economic Review 90, 429–457.

Uhlig, H., 2005. What are the effects of monetary policy on output? results from an agnostic identification procedure. Journal of Monetary Economics 52, 381–419.

Uhlig, H., 2017. Shocks, sign restrictions, and identification. Advances in Economics and Econometrics 2, 95.

Van Binsbergen, J. H., Schwert, M., 2021. Duration-based valuation of corporate bonds. Available at SSRN 3914422 .

Vuillemey, G., 2019. Bank interest rate risk management. Management Science 65, 5933–5956.

Woodford, M., 2003. Interest and Prices: Foundations of a Theory of Monetary Policy. Princeton University Press.

Zhu, Q., 2021. Capital supply and corporate bond issuances: Evidence from mutual fund flows. Journal of Financial Economics 141, 551–572.

Appendices

Appendix A Results of index bond funds

In this section, we explore how index bond fund flows respond to changes in interest rates. Compared to mutual funds investment, which is active investing, where fund managers play a significant role in picking and market-timing portfolios. Index funds investment instead is a form of passive investing, their portfolios largely follow the benchmark index. Therefore, we may observe different flow response patterns between mutual funds and index funds.

We first re-examine the response of index fund flows to lower interest rates. Table 16 shows our estimated results of index funds to changes in $\triangle FFR$. Columns (1)-(2) are the regression results for investment-grade index funds. The estimated coefficient of $\triangle FFR$ in column (1) is -7.366 and the estimated coefficient MPS is -13.701 in column (2). Moreover, both coefficients are statistically significant at the 10% level, which suggests that lower interest rates also lead to inflows to investment-grade index funds. By contrast, the estimated coefficients of $\triangle FFR$ and MPS for high-yield index funds are not statistically significant. So far, the relationship between index fund flows and changes in interest rates is in line with our results in mutual funds. Although the results are less statistically significant for index bond funds, investors still tend to buy more investment-grade bond index funds in response to a lower interest rate.

Next, we study the effects of credit risk and duration risk on index fund flows. The estimated coefficients of $\triangle FFR \times \triangle CreditSpread$ and $\triangle FFR \times Maturity$ in Table 17 are not statistically significant for all specifications. This suggests that index fund investors do not respond significantly to the effects of credit and duration risks, that is, in response to a lower interest rate, index fund investors are not buying lower-rated or longer-maturity bond funds. The reason for this may be related to the fact that index fund investors adjust their investments much less frequently.

Similarly, Table 18 presents estimated results of index funds when JK monetary policy shocks are used as the measure of the Fed's monetary policy stance. Consistent with our results in Table 17, estimated coefficients of $\triangle FFR \times \triangle CreditSpread$ and $\triangle FFR \times Maturity$ are not statistically significant for both investment-grade and high-yield index funds.

Overall, our results in this section suggest that following the decrease in the Fed's policy rate, although index fund investors still tend to buy more investment-grade bond funds, index fund flows are much less sensitive to changes in interest rates than mutual fund flows. More importantly, it seems that index fund investors are not adjusting their investments based on small changes in credit risks or duration risks. This can be explained by the fact that index funds mainly follow their benchmark index regardless of the state of the markets, investors seem to buy or sell these index funds in both rising and falling interest rate times.

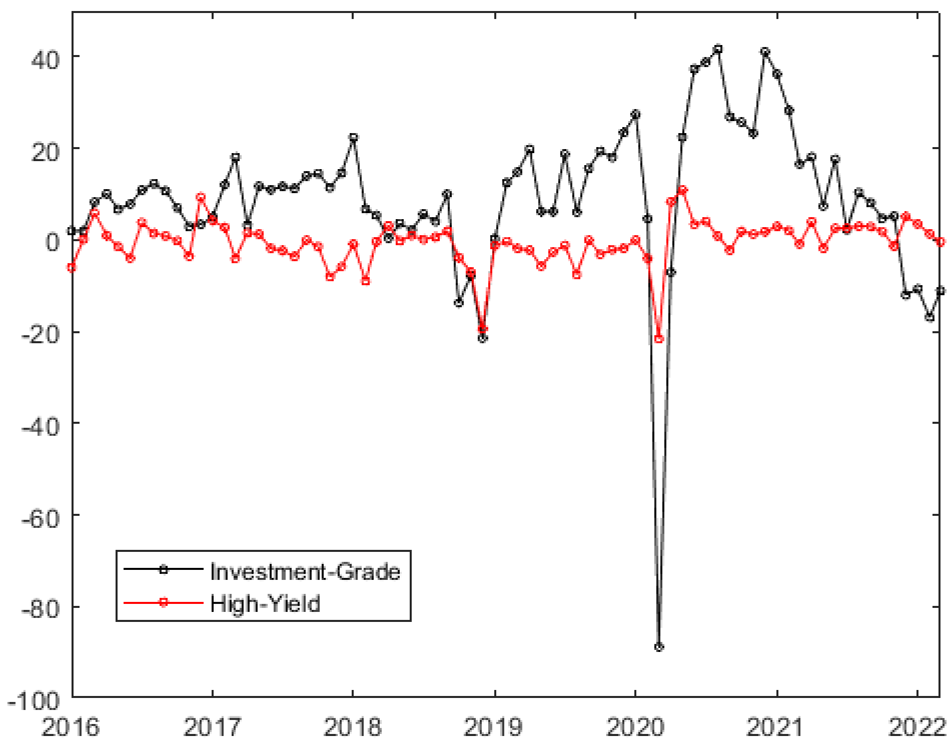

Figure 1: Monthly corporate bond mutual fund net flows (in billions of U.S. dollars).

Notes: The figure shows time series of monthly investment-grade and high-yield bond mutual fund net flows from January 2016 to March 2022.

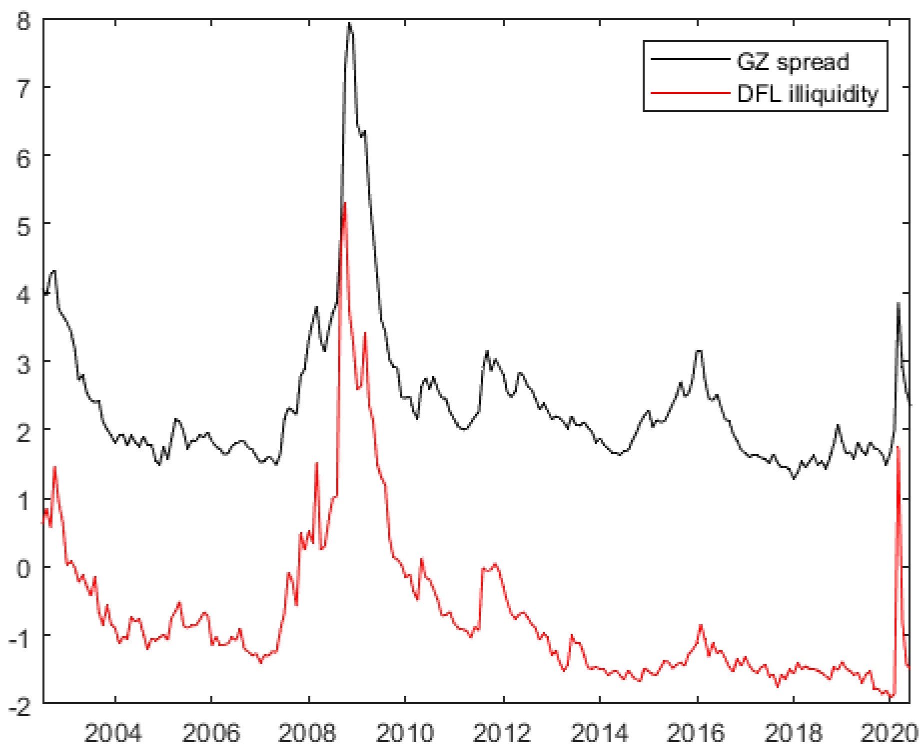

Figure 2: Time series of DFL illiquidity and GZ credit spread

Notes: The figure shows the time series of monthly GZ credit spread and DFL illiquidity from July 2002 to June 2020.

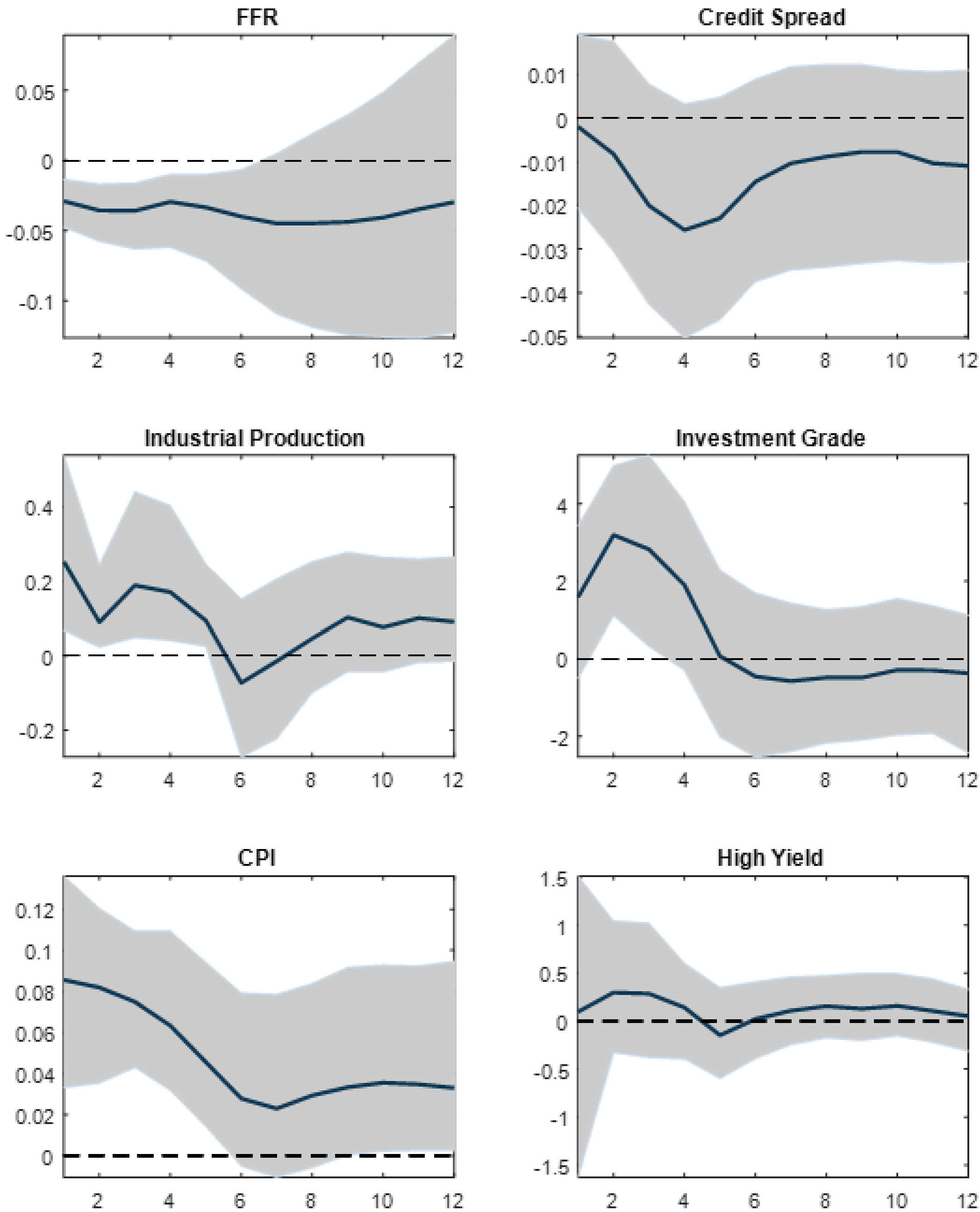

Figure 3: Impulse responses of fund flows to an expansionary monetary policy shock

Notes: This figure shows the impulse responses to a one standard deviation expansionary monetary policy shock. It shows the median as well as the 16% and the 84% quantiles for the sample of the impulse responses. The sample is from January 2016 to March 2022. The X-axis is the response time in months.

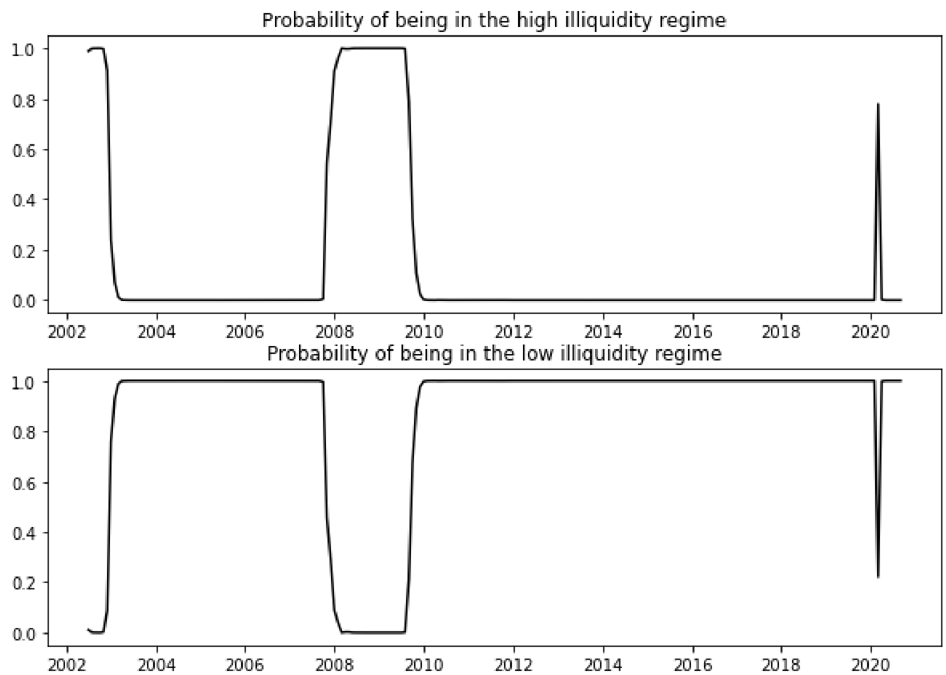

Figure 4: State probabilities in high and low illiquidity regime

Notes: This figure plots the time series of estimated probabilities in regime 0, the high illiquidity state, and in regime 1, the low illiquidity state.

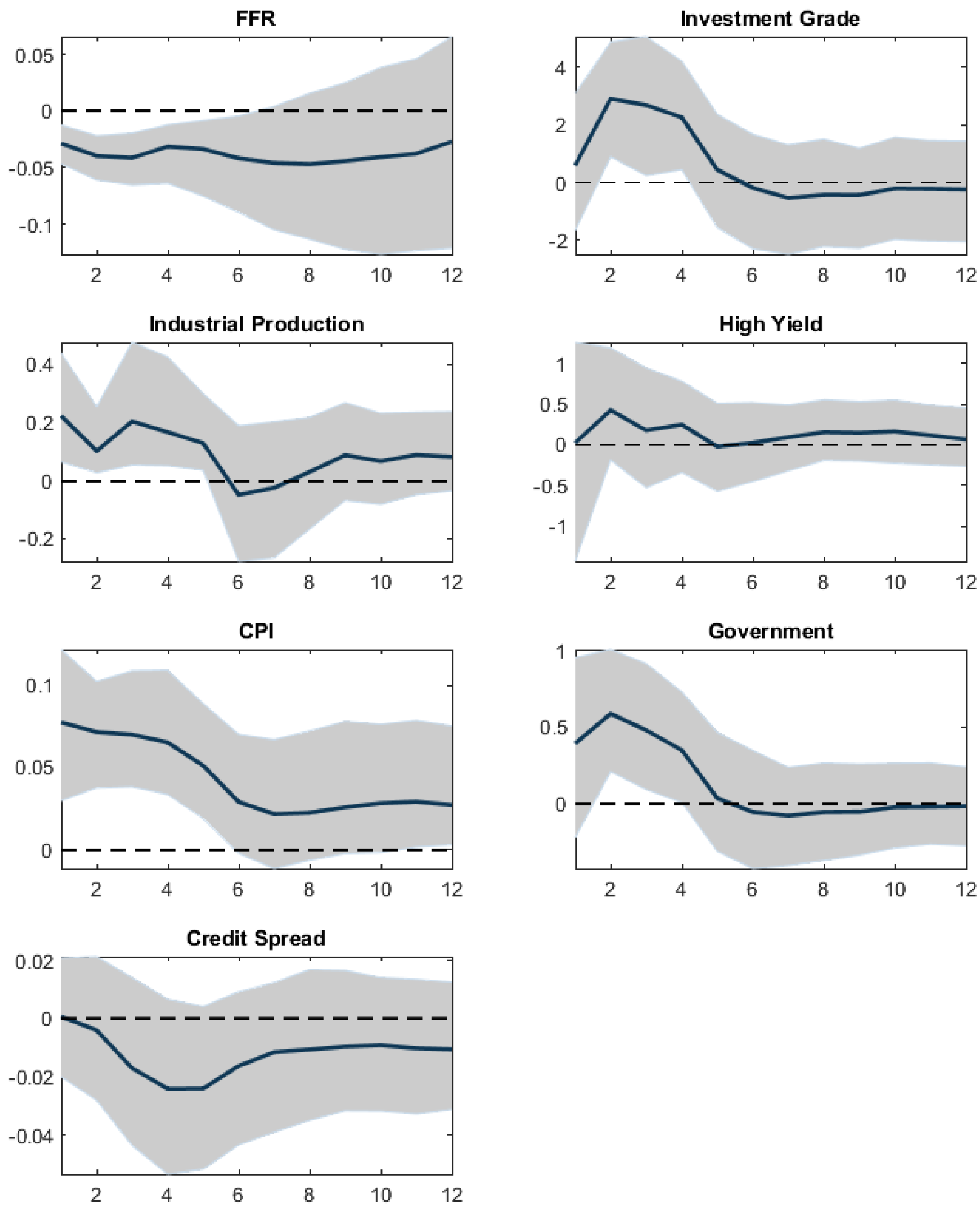

Figure 5: Impulse responses of fund flows to an expansionary monetary policy shock

Notes: This figure shows the impulse responses to a one standard deviation expansionary monetary policy shock. It shows the median as well as the 16% and the 84% quantiles for the sample of the impulse responses. The sample is from January 2016 to March 2022. The X-axis is the response time in months.

Table 1: Summary statistics

Variables	Mean	Median	St. Dev.	P25	P75	P90	N
			Panel A: Investment-Grade Funds				
Flow	1.75	0.07	17.92	-3.28	4.07	11.68	36,531
Return	0.26	0.31	2.98	-1.44	1.66	3.20	36,531
TNA	505.60	176.70	937.05	44.70	491.20	1168.44	36,531
Volatility	0.98	0.74	0.93	0.48	1.17	1.79	36,531
Expense Ratio	0.97	0.87	0.42	0.65	1.17	1.66	36,531
Turnover Ratio	132.74	67.00	198.63	31.00	172.00	276.00	36,531
Institution	0.27	0.00	0.45	0.00	1.00	1.00	36,531
Maturity	13.10	12.30	4.24	10.70	15.00	19.80	36,531
Distribution Yield	1.48	0.43	1.77	0.28	2.30	4.47	36,531
Cash Holdings	1.50	1.81	8.18	0.30	4.39	7.79	36,531
			Panel B: High-Yield Funds				
Flow	2.25	-0.37	20.16	-3.90	4.78	14.20	21,528
Return	-0.24	0.51	5.21	-2.30	2.10	4.20	21,528
TNA	931.36	259.00	1909.93	75.90	780.52	2294.85	21,528
Volatility	1.47	1.14	1.31	0.61	1.86	2.91	21,528
Expense Ratio	1.12	1.00	0.43	0.80	1.53	1.80	21,528
Turnover Ratio	71.11	57.00	64.54	40.00	86.00	117.00	21,528
Institution	0.25	0.00	0.43	0.00	0.00	1.00	21,528
Maturity	6.87	6.60	1.07	6.10	7.30	8.30	21,528
Distribution Yield	2.37	0.66	2.84	0.46	3.59	7.03	21,528
Cash Holdings	3.53	3.09	4.21	1.15	5.40	7.90	21,528

Notes: This table reports summary statistics for the corporate bond mutual fund sample. It includes the mean, median, standard deviation, and 25 percentile, 75 percentile, and 90 percentile. TNA represents the total net asset value of the fund in millions of U.S. dollars, return represents the quarterly return of a fund, and flow represents net inflows into the fund, which is calculated based on equation (5). Expense represents the fund expense ratio, turnover represents the fund turnover ratio, institution identifies if a fund is an institutional fund or retail fund, which is a dummy variable, volatility is the standard deviation of the fund return for the past quarter, maturity is the weighted average maturity in years, cash holdings is the amount of fund invested in cash, distribution yield is calculated as the ratio of distributions and fund's net asset value at the end of the period.

Table 2: Fund flows and change in FFR

	Investment-Grade Funds		High-Yield Funds	
	(1)	(2)	(3)	(4)
$\triangle FFR$	-1.502^{**}	-1.306^{**}	0.340	0.586
	(0.609)	(0.662)	(0.347)	(0.379)
CreditSpread		0.539		0.683^{*}
		(0.481)		(0.356)
Volatility	0.905	0.899	2.488^{***}	2.469^{***}
	(0.568)	(0.568)	(0.377)	(0.374)
Return	0.223^{***}	0.217^{***}	0.123^{***}	0.118^{**}
	(0.083)	(0.084)	(0.047)	(0.047)
Size	-6.330^{***}	-6.331^{***}	-6.918^{***}	-6.942^{***}
	(1.657)	(1.657)	(1.271)	(1.275)
Expense	3.518	3.451	-0.133	-0.214
	(3.832)	(3.838)	(5.167)	(5.168)
Turnover	0.003	0.002	-0.008^{*}	-0.008^{*}
	(0.004)	(0.004)	(0.005)	(0.005)
Institution	-2.736	-2.739	1.254	1.283
	(3.295)	(3.300)	(1.947)	(1.956)
Maturity	0.153	0.150	2.133^{***}	2.104^{***}
	(0.277)	(0.276)	(0.437)	(0.435)
Distribution	0.189	0.198	0.455^{***}	0.462^{***}
	(0.258)	(0.257)	(0.129)	(0.128)
Fund FEs	Yes	Yes	Yes	Yes
Observations	36,531	36,531	21,528	21,528
R^2	0.026	0.026	0.062	0.062

Notes: This table shows the relationship between fund flows (dependent variable) and $\triangle FFR$. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Fund flows with JK monetary policy shocks

	Investment-Grade Funds		High-Yield Funds	
	(1)	(2)	(3)	(4)
MPS	-5.224^{*}	-5.841^{**}	3.850	3.903
	(2.826)	(2.892)	(2.376)	(2.510)
CreditSpread		1.279^{***}		0.903^{**}
		(0.463)		(0.360)
Volatility	0.789	0.781	2.433^{***}	2.410^{***}
	(0.572)	(0.571)	(0.374)	(0.371)
Return	0.204^{**}	0.198^{**}	0.115^{**}	0.109^{**}
	(0.085)	(0.085)	(0.048)	(0.049)
Size	-6.495^{***}	-6.495^{***}	-6.864^{***}	-6.905^{***}
	(1.685)	(1.684)	(1.276)	(1.282)
Expense	4.298	4.043	−0.246	−0.434
	(4.042)	(4.042)	(5.321)	(5.322)
Turnover	0.002	0.002	-0.008^{*}	-0.008^{*}
	(0.005)	(0.005)	(0.005)	(0.005)
Institution	−2.847	−2.836	1.709	1.750
	(3.373)	(3.383)	(1.985)	(2.014)
Maturity	0.139	0.127	2.198^{***}	2.143^{***}
	(0.287)	(0.284)	(0.450)	(0.446)
Distribution	0.160	0.182	0.455^{***}	0.462^{***}
	(0.261)	(0.259)	(0.130)	(0.130)
Fund FEs	Yes	Yes	Yes	Yes
Observations	34,692	34,692	20,647	20,647
R^2	0.026	0.025	0.062	0.063

Notes: This table shows the relationship between fund flows (dependent variable) and JK monetary policy shocks (MPS). Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Interest rate sensitivity

	Investment-Grade Funds				High-Yield Funds			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$-\triangle FFR$	0.424***	0.444***	0.751***	0.837***	0.143***	0.169***	0.504***	0.597***
	(0.026)	(0.024)	(0.044)	(0.050)	(0.015)	(0.014)	(0.020)	(0.020)
DEF	0.079***	0.081***	0.265***	0.334***	0.051***	0.059***	0.240***	0.325***
	(0.008)	(0.009)	(0.018)	(0.024)	(0.004)	(0.004)	(0.006)	(0.007)
MktRF	0.153***	0.135***	0.053***	0.022***	0.479***	0.442***	0.369***	0.305***
	(0.010)	(0.009)	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)	(0.006)
SMB		0.062***		0.078***		0.142***		0.248***
		(0.007)		(0.010)		(0.005)		(0.006)
HML		0.049***		−0.145***		0.074***		−0.109***
		(0.009)		(0.014)		(0.005)		(0.005)
Fund FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	89,327	89,327	57,359	57,359	54,741	54,741	41,286	41,286
R^2	0.539	0.551	0.485	0.528	0.598	0.619	0.530	0.588

Notes: This table shows regression results of fund returns on the negative change of FFR and other factors. Columns (1)-(4) are the estimated results for investment-grade funds, and columns (5)-(8) are the estimated results for high-yield funds. Columns (1), (2), (5), and (6) are the results of the full sample, and columns (3), (4), (7), and (8) are the results of the sub-sample (without zero lower bound period). Standard errors (in parentheses) are clustered at the fund level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5: Credit risk and duration risk effects with change in FFR

	Investment-Grade Funds			High-Yield Funds		
	(1)	(2)	(3)	(4)	(5)	(6)
$\triangle FFR$	-2.405^{***}		-0.246	0.196		-2.945
	(0.851)		(1.127)	(0.420)		(2.392)
$\triangle CreditSpread$	0.740		0.745	3.988^{***}		3.964^{***}
	(0.909)		(0.909)	(0.790)		(0.791)
Volatility	0.910	-0.950	0.903	2.383^{***}	-1.885^{**}	2.385^{***}
	(0.568)	(1.178)	(0.569)	(0.376)	(0.929)	(0.376)
Return	0.239^{***}	0.400^{*}	0.239^{***}	0.132^{***}	0.832^{***}	0.132^{***}
	(0.084)	(0.209)	(0.085)	(0.048)	(0.190)	(0.048)
Size	-6.450^{***}	-6.219^{***}	-6.463^{***}	-6.596^{***}	-6.180^{***}	-6.582^{***}
	(1.691)	(1.790)	(1.692)	(1.272)	(1.271)	(1.272)
Expense	3.646	-0.811	3.538	-0.753	-6.256	-0.745
	(3.882)	(4.276)	(3.882)	(5.088)	(4.643)	(5.077)
Turnover	0.002	0.001	0.002	-0.008^{*}	-0.008	-0.008^{*}
	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
Institution	-2.983	-1.786	-3.003	1.299	1.899	1.308
	(3.370)	(3.324)	(3.370)	(1.895)	(2.190)	(1.894)
Maturity	0.150	0.033	0.148	2.163^{***}	1.422^{***}	2.214^{***}
	(0.280)	(0.272)	(0.279)	(0.428)	(0.538)	(0.440)
Distribution	0.043	-0.655	0.044	0.363^{***}	-0.296	0.365^{***}
	(0.272)	(0.927)	(0.272)	(0.132)	(0.412)	(0.132)
$\triangle FFR \times \triangle CreditSpread$	3.104^{***}		3.133^{***}	3.199^{***}		3.133^{***}
	(1.125)		(1.130)	(0.715)		(0.712)
$\triangle FFR \times Maturity$		-0.178^{**}	-0.166^{**}		0.310	0.466
		(0.077)	(0.076)		(0.373)	(0.340)
Fund FEs	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FEs	No	Yes	No	No	Yes	No
Observations	36,531	36,531	36,531	21,528	21,528	21,528
R^2	0.026	0.017	0.026	0.058	0.024	0.058

Notes: Columns (1)-(3) are the regression results for investment-grade funds, and columns (4)-(6) are the regression results for high-yield funds. Columns (1) and (4) show the effect of credit risk. Columns (2) and (5) show the effect of duration risk. Columns (3) and (6) show the effects of both credit risk and duration risk. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6: Credit risk and duration risk effects with JK monetary policy shocks

	Investment-Grade Funds			High-Yield Funds		
	(1)	(2)	(3)	(4)	(5)	(6)
MPS	-4.134		-22.862^{**}	-9.648^{***}		5.931
	(3.415)		(11.280)	(2.763)		(16.109)
$\triangle CreditSpread$	1.407		1.426	4.035^{***}		4.037^{***}
	(1.063)		(1.065)	(0.892)		(0.894)
Volatility	0.773	-0.925	0.780	2.318^{***}	-1.919^{**}	2.317^{***}
	(0.570)	(1.197)	(0.571)	(0.372)	(0.929)	(0.373)
Return	0.207^{**}	0.368^{*}	0.204^{**}	0.119^{**}	0.836^{***}	0.119^{**}
	(0.085)	(0.215)	(0.085)	(0.049)	(0.191)	(0.049)
Size	-6.586^{***}	-6.376^{***}	-6.586^{***}	-6.531^{***}	-6.177^{***}	-6.531^{***}
	(1.712)	(1.828)	(1.714)	(1.277)	(1.276)	(1.277)
Expense	4.473	0.005	4.417	-1.074	-6.546	-1.065
	(4.109)	(4.391)	(4.114)	(5.234)	(4.811)	(5.234)
Turnover	0.001	0.001	0.002	-0.008^{*}	-0.008	-0.008^{*}
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Institution	-3.072	-1.785	-3.021	1.730	2.271	1.727
	(3.463)	(3.407)	(3.442)	(1.969)	(2.230)	(1.970)
Maturity	0.135	-0.047	0.103	2.205^{***}	1.403^{**}	2.215^{***}
	(0.288)	(0.275)	(0.288)	(0.442)	(0.549)	(0.451)
Distribution	0.049	-0.692	0.050	0.368^{***}	-0.263	0.368^{***}
	(0.269)	(0.943)	(0.268)	(0.134)	(0.417)	(0.134)
$MPS \times \triangle CreditSpread$	4.354		4.557	8.276^{**}		8.249^{**}
	(4.924)		(4.965)	(3.868)		(3.841)
$MPS \times Maturity$		-1.391^{**}	-1.431^{*}		1.615	0.537
		(0.702)	(0.733)		(2.252)	(2.110)
Fund FEs	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FEs	No	Yes	No	No	Yes	No
Observations	34,692	34,692	34,692	20,647	20,647	20,647
R^2	0.024	0.018	0.025	0.059	0.024	0.059

Notes: Columns (1)-(3) are the regression results for investment-grade funds, and columns (4)-(6) are the regression results for high-yield funds. Columns (1) and (4) show the effect of credit risk. Columns (2) and (5) show the effect of duration risk. Columns (3) and (6) show the effects of both credit risk and duration risk. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7: Markov switching model results

	μ_0	μ_1	p_{00}	p_{10}
l_{DFL}	1.598	-1.064	0.931	0.014

Notes: This table shows the Markov regime-switching model results. μ_0 denotes the mean value in regime 0, the high illiquidity state, μ_1 denotes the mean value in regime 1, the low illiquidity state, p_{00} denotes the transition probability from the current 0 regime to stay at regime 0 in the next period, p_{10} denotes the transition probability from current 1 regime to regime 0 in the next period.

Table 8: Flight-to-safety (FTS) effects

	Investment-Grade Funds		High-Yield Funds	
	(1)	(2)	(3)	(4)
$\triangle FFR$	-1.306^{**}	-1.799^{*}	0.586	-0.414
	(0.662)	(1.044)	(0.379)	(0.528)
CreditSpread	0.539	0.585	0.683^{*}	0.552
	(0.481)	(1.120)	(0.356)	(1.019)
Volatility	0.899	0.858	2.469^{***}	1.970^{***}
	(0.568)	(0.617)	(0.374)	(0.373)
Return	0.217^{***}	0.228^{***}	0.118^{**}	0.023
	(0.084)	(0.088)	(0.047)	(0.050)
Size	-6.331^{***}	-6.863^{***}	-6.942^{***}	-5.827^{***}
	(1.657)	(1.993)	(1.275)	(1.369)
Expense	3.451	3.235	-0.214	0.188
	(3.838)	(3.830)	(5.168)	(4.997)
Turnover	0.002	0.002	-0.008^{*}	0.001
	(0.004)	(0.004)	(0.005)	(0.004)
Institution	-2.739	-3.579	1.283	1.156
	(3.300)	(3.978)	(1.956)	(1.683)
Maturity	0.150	0.116	2.104^{***}	2.345^{***}
	(0.276)	(0.279)	(0.435)	(0.448)
Distribution	0.198	0.184	0.462^{***}	0.283^{*}
	(0.257)	(0.369)	(0.128)	(0.164)
Fund FEs	Yes	Yes	Yes	Yes
Observations	36,531	31,462	21,528	18,549
R^2	0.026	0.026	0.062	0.047

Notes: This table shows the effects of the flight-to-safety (FTS) period on the relationship between fund flows and the change in FFR. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Columns (1) and (3) are the results of the full sample, and columns (2) and (4) are the results of the sub-sample (without the FTS period). Standard errors (in parentheses) are clustered at the fund level and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 9: Fed information effects

	Investment-Grade Funds		High-Yield Funds	
	(1)	(2)	(3)	(4)
MPS	-5.841^{**}		3.903	
	(2.892)		(2.510)	
CBI		0.317		20.893^{**}
		(9.307)		(8.146)
CreditSpread	1.279^{***}	1.017^{**}	0.903^{**}	0.823^{**}
	(0.463)	(0.499)	(0.360)	(0.339)
Volatility	0.781	0.829	2.410^{***}	2.478^{***}
	(0.571)	(0.571)	(0.371)	(0.380)
Return	0.198^{**}	0.197^{**}	0.109^{**}	0.136^{***}
	(0.085)	(0.082)	(0.049)	(0.048)
Size	-6.495^{***}	-6.514^{***}	-6.905^{***}	-6.880^{***}
	(1.684)	(1.689)	(1.282)	(1.287)
Expense	4.043	4.132	−0.434	−0.291
	(4.042)	(4.049)	(5.322)	(5.333)
Turnover	0.002	0.002	-0.008^{*}	−0.008
	(0.005)	(0.005)	(0.005)	(0.005)
Institution	−2.836	−2.865	1.750	1.644
	(3.383)	(3.392)	(2.014)	(2.014)
Maturity	0.127	0.130	2.143^{***}	2.191^{***}
	(0.284)	(0.285)	(0.446)	(0.452)
Distribution	0.182	0.183	0.462^{***}	0.503^{***}
	(0.259)	(0.271)	(0.130)	(0.126)
Fund FEs	Yes	Yes	Yes	Yes
Observations	34,692	34,692	20,647	20,647
R^2	0.026	0.025	0.063	0.062

Notes: This table shows the comparison between Fed monetary policy shocks and information shocks on the fund flows. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Columns (1) and (3) are the results of the monetary policy shocks and columns (2) and (4) are the results of the information shocks. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 10: Fund flows, $\triangle FFR$, and the effects of maturity

	Investment-Grade Funds		High-Yield Funds	
	(1)	(2)	(3)	(4)
$\triangle FFR$	-11.466^{***}		-8.571	
	(2.692)		(5.442)	
CreditSpread	1.633		-1.473	
	(4.295)		(10.655)	
Volatility	-0.007	-0.025^{*}	-0.065^{***}	-0.038^{**}
	(0.020)	(0.014)	(0.017)	(0.016)
Return	0.092	0.196^{***}	0.286^{***}	0.127^{**}
	(0.126)	(0.058)	(0.084)	(0.056)
Size	-61.881^{***}	-62.451^{***}	-48.416^{***}	-48.768^{***}
	(19.568)	(19.526)	(16.358)	(16.417)
Expense	-15.783	-15.455	28.652	20.586
	(17.318)	(16.844)	(35.281)	(33.500)
Turnover	0.007	0.007	0.024	0.021
	(0.006)	(0.006)	(0.016)	(0.014)
inst	4.669	4.424	0.145	-1.360
	(5.086)	(5.185)	(2.709)	(2.924)
Maturity	-2.076^{***}	-1.259^{*}	-0.308	1.000
	(0.649)	(0.754)	(0.583)	(0.711)
Distribution	-2.567	-2.544	0.486	0.744
	(3.354)	(3.300)	(1.221)	(1.155)
$\triangle FFR \times Maturity$		-0.770^{**}		-1.862
		(0.366)		(1.312)
Fund FEs	Yes	Yes	Yes	Yes
Quarter FEs	No	Yes	No	Yes
Observations	15,147	15,147	5,564	5,564
R^2	0.017	0.017	0.078	0.077

Notes: Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Columns (1) and (3) show the relationship between fund flows and the change in FFR and columns (2) and (4) show the effects of maturity. Standard errors (in parentheses) are clustered at the fund level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 11: Short-term investment-grade bond fund flows and $\triangle FFR$

	(1)	(2)
Short	1.681	0.356
	(3.075)	(2.336)
Volatility	-0.027^{*}	-0.025^{*}
	(0.014)	(0.014)
Return	0.186^{***}	0.184^{***}
	(0.057)	(0.057)
Size	-61.464^{***}	-61.866^{***}
	(19.394)	(19.515)
Expense	-10.566	-12.067
	(17.090)	(17.186)
Turnover	0.008	0.007
	(0.007)	(0.006)
Institution	4.197	3.882
	(5.208)	(5.177)
Distribution	-2.764	-2.766
	(3.348)	(3.343)
$\triangle FFR \times Short$	6.303^{*}	7.496^{**}
	(3.447)	(3.701)
Fund FEs	Yes	Yes
Quarter FEs	Yes	Yes
Observations	15,147	15,147
R^2	0.017	0.017

Notes: Column (1) shows the relationship between these investment-grade fund flows with a maturity of fewer than 5 years and $\triangle FFR$. Column (2) shows the same relationship but with a maturity of fewer than 10 years. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 12: Relationship between long-term and short-term bond fund flows

	(1)	(2)	(3)
long-term flows	0.003	−0.125	-0.014^{***}
	(0.003)	(0.109)	(0.002)
Fund FEs	Yes	Yes	Yes
Quarter FEs	Yes	Yes	Yes
Observations	7,477	4,170	3,307
R^2	0.001	0.001	0.001

Notes: This table shows the response of short-term investment-grade bond fund flows to long-term bond fund flows. Column (1) shows the results with a full sample (Q4 2020 to Q4 2022), column (2) shows the results with a subsample (Q4 2020 to Q4 2021), and column (3) shows the results with rising interest rates periods (Q1 2022 to Q4 2022). Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 13: Fund flows and change of GS10

	Investment-Grade Funds		High-Yield Funds	
	(1)	(2)	(3)	(4)
$\triangle GS10$	-2.988^{**}	-2.802^{*}	0.983	-0.113
	(1.170)	(1.673)	(0.625)	(0.910)
CreditSpread	0.870^{*}	1.067	0.632^{*}	0.715
	(0.491)	(1.889)	(0.357)	(1.160)
Volatility	0.874	0.845	2.469^{***}	1.961^{***}
	(0.571)	(0.616)	(0.378)	(0.370)
Return	0.219^{**}	0.252^{**}	0.101^{**}	0.025
	(0.095)	(0.108)	(0.051)	(0.060)
Size	-6.321^{***}	-6.862^{***}	-6.934^{***}	-5.825^{***}
	(1.665)	(2.001)	(1.277)	(1.369)
Expense	3.466	3.256	-0.214	0.198
	(3.851)	(3.923)	(5.178)	(5.010)
Turnover	0.002	0.002	-0.007	0.001
	(0.004)	(0.004)	(0.005)	(0.004)
Institution	-2.752	-3.573	1.256	1.149
	(3.296)	(3.972)	(1.997)	(1.672)
Maturity	0.148	0.119	2.116^{***}	2.342^{***}
	(0.277)	(0.281)	(0.438)	(0.450)
Distribution	0.198	0.177	0.461^{***}	0.283^{*}
	(0.252)	(0.373)	(0.128)	(0.167)
Fund FEs	Yes	Yes	Yes	Yes
Observations	36,531	36,531	21,528	21,528
R^2	0.026	0.026	0.063	0.047

Notes: This table shows the robustness test of the relationship between fund flows and change of 10-year interest rate GS10. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Columns (1) and (3) are the results of the full-sample and columns (2) and (4) are the results of the sub-sample (without the FTS period). Standard errors (in parentheses) are clustered at the fund level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 14: Interest rate sensitivity with GS10

	Investment-Grade Funds		High-Yield Funds	
	(1)	(2)	(3)	(4)
$-\triangle GS10$	0.250***	0.292***	0.049***	0.050***
	(0.036)	(0.037)	(0.006)	(0.006)
DEF	0.042***	0.044***	0.030***	0.036***
	(0.007)	(0.008)	(0.003)	(0.003)
MktRF	0.148***	0.130***	0.478***	0.441***
	(0.010)	(0.009)	(0.007)	(0.007)
SMB		0.064***		0.144***
		(0.007)		(0.005)
HML		0.048***		0.070***
		(0.009)		(0.005)
Fund FEs	Yes	Yes	Yes	Yes
Observations	89,327	89,327	54,741	54,741
R^2	0.534	0.546	0.600	0.619

Notes: This table shows the regression results of fund returns to the negative change of GS10 and other factors. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Standard errors (in parentheses) are clustered at the fund level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 15: Credit risk and duration risk effects with change of GS10

	Investment-Grade Funds			High-Yield Funds		
	(1)	(2)	(3)	(4)	(5)	(6)
$\triangle GS10$	-1.272		-2.228	-1.526^{**}		-1.782
	(1.267)		(2.869)	(0.700)		(3.988)
$\triangle CreditSpread$	-0.330		-0.333	3.149^{***}		3.112^{***}
	(0.699)		(0.701)	(0.670)		(0.675)
Volatility	0.883	-0.907	0.885	2.378^{***}	-1.881^{**}	2.384^{***}
	(0.575)	(1.168)	(0.577)	(0.379)	(0.933)	(0.380)
Return	0.228^{**}	0.399^{*}	0.228^{**}	0.101^{*}	0.830^{***}	0.102^{**}
	(0.099)	(0.209)	(0.099)	(0.052)	(0.190)	(0.052)
Size	-6.431^{***}	-6.201^{***}	-6.429^{***}	-6.584^{***}	-6.193^{***}	-6.591^{***}
	(1.696)	(1.790)	(1.697)	(1.278)	(1.273)	(1.280)
Expense	3.749	-0.720	3.734	-0.763	-6.286	-0.823
	(3.937)	(4.276)	(3.943)	(5.094)	(4.664)	(5.095)
Turnover	0.002	0.001	0.002	-0.007	-0.008	-0.007
	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
Institution	-3.014	-1.760	-3.010	1.207	1.895	1.208
	(3.372)	(3.313)	(3.364)	(1.953)	(2.189)	(1.959)
Maturity	0.155	0.039	0.159	2.181^{***}	1.379^{**}	2.211^{***}
	(0.283)	(0.273)	(0.283)	(0.433)	(0.538)	(0.446)
Distribution	0.094	-0.665	0.094	0.362^{***}	-0.308	0.361^{***}
	(0.264)	(0.927)	(0.264)	(0.133)	(0.413)	(0.133)
$\triangle GS10 \times \triangle CreditSpread$	0.490		0.479	3.341^{***}		3.305^{***}
	(1.941)		(1.926)	(1.209)		(1.219)
$\triangle GS10 \times Maturity$		-0.368^{**}	-0.373^{**}		-0.075	0.482
		(0.169)	(0.173)		(0.590)	(0.592)
Fund FEs	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FEs	No	Yes	No	No	Yes	No
Observations	36,531	36,531	36,531	21,528	21,528	21,528
R^2	0.024	0.017	0.024	0.058	0.024	0.058

Notes: Columns (1)-(3) are the regression results for investment-grade funds, and columns (4)-(6) are the regression results for high-yield funds. Columns (1) and (4) show the effect of credit risk. Columns (2) and (5) show the effect of duration risk. Columns (3) and (6) show the effects of both credit risk and duration risk. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 16: Lower interest rates and index fund flows

	Investment-Grade Funds		High-Yield Funds	
	(1)	(2)	(3)	(4)
$\triangle FFR$	-7.366^{*}		-4.526	
	(4.063)		(20.544)	
MPS		-13.701^{*}		-65.052
		(7.459)		(39.425)
CreditSpread	0.726	1.777	-9.826	-5.393
	(1.931)	(1.925)	(13.359)	(13.984)
Volatility	0.356^{*}	0.382^{**}	0.099	0.101
	(0.187)	(0.195)	(0.064)	(0.065)
Return	0.278^{**}	0.324^{**}	0.066	0.062
	(0.140)	(0.155)	(0.092)	(0.094)
Size	-4.588^{***}	-4.960^{***}	-27.886^{**}	-27.989^{**}
	(1.429)	(1.408)	(12.425)	(12.443)
Expense	-47.520^{**}	-43.122^{*}	-210.318^{***}	-211.361^{***}
	(23.985)	(22.537)	(62.311)	(64.186)
Turnover	0.013	0.013	0.023^{**}	0.023^{**}
	(0.017)	(0.017)	(0.010)	(0.010)
Institution	-6.704	-6.815		
	(5.262)	(5.300)		
Maturity	2.477^{***}	2.252^{**}	0.745	0.771
	(0.948)	(0.992)	(0.636)	(0.590)
Distribution	2.252	1.998	-3.254	-4.879^{*}
	(1.823)	(1.859)	(2.951)	(2.904)
Fund FEs	Yes	Yes	Yes	Yes
Observations	36,531	34,692	21,528	20,647
R^2	0.033	0.032	0.046	0.047

Notes: This table shows the relationship between fund flows, $\triangle FFR$, and JK monetary policy shocks (MPS) for index funds. Columns (1)-(2) are the estimated results for investment-grade funds, and columns (3)-(4) are the estimated results for high-yield funds. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 17: Credit risk and duration risk effects with change in FFR for index funds

	Investment-Grade Funds			High-Yield Funds		
	(1)	(2)	(3)	(4)	(5)	(6)
$\triangle FFR$	-10.006^{**}		-14.396^{*}	-20.824		-26.998
	(4.256)		(8.021)	(17.476)		(19.677)
$\triangle CreditSpread$	6.283^{**}		6.233^{**}	34.097^{*}		33.966^{*}
	(3.164)		(3.166)	(20.541)		(20.553)
Volatility	0.428^{**}	0.333^{*}	0.428^{**}	0.137^{**}	0.127^{**}	0.137^{**}
	(0.194)	(0.195)	(0.193)	(0.055)	(0.050)	(0.055)
Return	0.333^{**}	0.423^{**}	0.334^{**}	0.112	0.101	0.112
	(0.144)	(0.199)	(0.144)	(0.159)	(0.152)	(0.159)
Size	-4.599^{***}	-3.821^{**}	-4.574^{***}	-22.668^{**}	-22.112^{**}	-22.573^{**}
	(1.432)	(1.486)	(1.424)	(10.484)	(10.750)	(10.488)
Expense	-45.384^{*}	-55.068^{**}	-46.165^{*}	-210.350^{***}	-176.942^{***}	-207.462^{***}
	(23.805)	(27.186)	(23.616)	(63.992)	(67.707)	(64.219)
Turnover	0.009	0.015	0.010	0.025^{*}	0.023^{*}	0.025^{*}
	(0.017)	(0.017)	(0.017)	(0.015)	(0.014)	(0.014)
Institution	-6.529	-7.010	-6.493			
	(5.314)	(5.069)	(5.326)			
Maturity	2.454^{***}	3.043^{***}	2.428^{***}	0.418	0.575^{*}	0.440
	(0.924)	(0.938)	(0.920)	(0.384)	(0.336)	(0.418)
Distribution	1.699	0.958	1.766	-6.716^{*}	-5.960	-6.741^{*}
	(1.703)	(1.719)	(1.707)	(3.617)	(5.086)	(3.725)
$\triangle FFR \times \triangle CreditSpread$	45.688		45.625	59.834		57.931
	(34.196)		(34.202)	(50.557)		(50.155)
$\triangle FFR \times Maturity$		0.425	0.414		0.922	0.901
		(0.593)	(0.596)		(0.589)	(0.639)
Fund FEs	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FEs	No	Yes	No	No	Yes	No
Observations	36,531	36,531	36,531	21,528	21,528	21,528
R^2	0.038	0.026	0.038	0.054	0.046	0.055

Notes: Columns (1)-(3) are the regression results for investment-grade funds, and columns (4)-(6) are the regression results for high-yield funds. Columns (1) and (4) show the effect of credit risk. Columns (2) and (5) show the effect of duration risk. Columns (3) and (6) show the effects of both credit risk and duration risk. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 18: Credit risk and duration risk effects with JK monetary policy shocks for index funds

	Investment-Grade Funds			High-Yield Funds		
	(1)	(2)	(3)	(4)	(5)	(6)
MPS	-11.074		-37.997^{*}	-72.258^{*}		-56.043
	(10.569)		(19.632)	(37.628)		(49.257)
$\triangle CreditSpread$	7.948^{**}		7.866^{**}	32.377^{*}		32.369^{*}
	(3.414)		(3.423)	(17.590)		(17.611)
Volatility	0.424^{**}	0.283	0.385^{**}	0.132^{**}	0.128^{**}	0.132^{**}
	(0.197)	(0.196)	(0.195)	(0.053)	(0.050)	(0.053)
Return	0.358^{**}	0.371^{**}	0.321^{**}	0.113	0.101	0.115
	(0.157)	(0.186)	(0.152)	(0.162)	(0.153)	(0.163)
Size	-5.059^{***}	-3.848^{**}	-5.050^{***}	-22.931^{**}	-22.246^{**}	-22.957^{**}
	(1.408)	(1.495)	(1.408)	(10.395)	(10.719)	(10.378)
Expense	-41.756^{*}	-53.837^{*}	-41.524^{*}	-208.655^{***}	-182.059^{***}	-210.044^{***}
	(22.108)	(27.645)	(22.305)	(63.983)	(67.483)	(63.739)
Turnover	0.009	0.014	0.009	0.026^{*}	0.023^{*}	0.026^{*}
	(0.017)	(0.018)	(0.017)	(0.015)	(0.014)	(0.015)
Institution	-6.780	-7.019	-6.750			
	(5.343)	(4.974)	(5.253)			
Maturity	2.247^{**}	3.012^{***}	2.197^{**}	0.450	0.677^{*}	0.550
	(0.991)	(0.941)	(0.989)	(0.395)	(0.406)	(0.410)
Distribution	1.550	0.996	1.665	-8.027^{**}	-6.070	-8.112^{**}
	(1.808)	(1.725)	(1.819)	(3.191)	(5.025)	(3.216)
$MPS \times \triangle CreditSpread$	40.583		37.744	339.176		341.557
	(54.715)		(54.894)	(264.143)		(264.886)
$MPS \times Maturity$		-2.485	-2.660		3.928	3.162
		(1.586)	(1.629)		(3.753)	(3.928)
Fund FEs	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FEs	No	Yes	No	No	Yes	No
Observations	34,692	34,692	34,692	20,647	20,647	20,647
R^2	0.035	0.027	0.036	0.054	0.046	0.054

Notes: Columns (1)-(3) are the regression results for investment-grade funds, and columns (4)-(6) are the regression results for high-yield funds. Columns (1) and (4) show the effect of credit risk. Columns (2) and (5) show the effect of duration risk. Columns (3) and (6) show the effects of both credit risk and duration risk. Standard errors (in parentheses) are clustered at the fund and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.