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Monetary policy and fragility in corporate bond mutual funds ☆

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ABSTRACT

We document aggregate outflows from corporate bond mutual funds days before and after the announcement of increases in the Federal Funds Target rate (FFTar). To rationalize this phenomenon, we build a model in which funds' net-asset-values (NAVs) are stale and investors strategically redeem to profit from the mispricing when they learn about the increases of FFTar. Consistent with the model's predictions, we find that stale NAVs and loose monetary policy environments weaken (strengthen) outflows sensitivity to increases in FFTar during illiquid (liquid) market conditions. Our results highlight when and how monetary policy could systematically exacerbate the fragility of corporate bond funds.

1. Introduction

Researchers have found that monetary policy has a significant impact on asset prices, credit allocations, and stability in the banking sector.[1] In this paper, we show that increases in the Federal Funds Target rate (FFTar) are associated with sizeable outflows from non-bank financial intermediaries, specifically corporate bond mutual funds. A useful comparison to assess the economic significance of this phenomenon is the deposit channel of monetary policy (Drechsler et al., 2017). Like banks, corporate bond funds engage in liquidity transformation by holding long-term assets while issuing demandable claims to investors. As of June 2023, the size of corporate bond funds has grown to over 3 trillion United States Dollars, approximately one-fifth of bank deposits (see Fig. 1). Notably, the sensitivity of fund outflows to changes in FFTar is *twice* that of bank deposits (see Table 3). These stylized facts raise concerns regarding corporate bond funds' fragility, the potential illiquidity spillovers to financial markets, and the negative impact on credit supply to the broader economy when monetary policy tightens.[2]

To capture the driving forces behind this phenomenon, henceforth the outflow–ΔFFTar sensitivity, we propose a mechanism based on the

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[1] For example, monetary policy is shown to affect equity and credit risk premia, Treasury term premia, leverage, and risk-taking choices by financial intermediaries. See the surveys by Kashyap and Stein (2023) and Bauer et al. (2023).

[2] Ma et al. (2022a) quantify the liquidity transformation of bond mutual funds relative to bank deposits. Massa et al. (2013) and Zhu (2021) show that corporate bond mutual funds matter for credit supply, and Fang (2022) quantifies the magnitude of the monetary policy transmission mechanism via corporate bond funds. Bond funds have exhibited significant fragility during the bond market disruption in the Covid-19 crisis (Falato et al., 2021; Haddad et al., 2021; Kargar et al., 2021). The Federal Reserve intervened and stabilized the market by creating corporate credit facilities (O'Hara and Zhou, 2021; Boyarchenko et al., 2022; Gilchrist et al., 2024).

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stale pricing of fund shares. Consider Federal Open Market Committee (FOMC) meetings with increases in the FFTar. We argue that the market learns about the FFTar increases days before the meetings but prices of fund shares, i.e., net-asset values (NAVs), do not adjust downwards immediately, and the shares are thus temporarily overpriced. As the NAVs will subsequently decline, investors preemptively redeem their shares. We empirically identify the above mechanism by conducting an event study in a narrow window around FOMC meetings using daily flow data. Our analysis comprises three key steps. First, we establish that changes in market interest rates, in particular, the 30-day Eurodollar Futures rate, predict future changes in FFTar. This finding suggests that new information about the future FFTar is revealed in the market days prior to the meetings. Second, we show that NAVs of fund shares are stale and do not promptly adjust fully in response to the new information.[3] Specifically, the aforementioned changes in the Eurodollar rates can predict a subsequent decline in the NAVs, and such predictive power persists until one week after the meetings. This indicates that the fund shares are temporarily overpriced, typically within a 10-day window around FOMC meetings. Third, we find evidence consistent with the notion that investors strategically redeem their shares to profit from the temporary overpricing: the same changes in the Eurodollar rates also predict outflows *before* and *after* the meetings. In addition, consistent with the stale pricing mechanism, the outflow response is stronger for funds with higher staleness.

We provide further supportive evidence for our mechanism in Section 2.4. For example, we find no significant outflow–ΔFFTar relationship in equity funds. This negative result is consistent with the stale pricing mechanism — as NAVs of equity funds exhibit little staleness[4] — and helps to rule out alternative channels through which monetary policy could cause aggregate portfolio reallocation from fixed-income assets to other assets, such as equities. In addition, we show that our results are not driven by the reaching-for-yield channel in corporate bond funds as documented in Choi and Kronlund (2018). Overall, our event study and cross-sectional analyses strongly support the stale pricing mechanism. It is worth noting that our results highlight a hitherto under-explored monetary policy transmission channel that occurs in corporate bond mutual funds *days prior to* the FOMC meetings when news about FFTar changes is learned by the market. It complements the monetary policy literature, which emphasizes how surprises revealed in the FOMC meetings affect treasury prices (Kuttner, 2001) and equity prices (Bernanke and Kuttner, 2005).

The magnitude of the outflow response reported as a percentage of funds' total net assets, is economically significant. Using changes in the Eurodollar Futures to predict future FFTar changes, we find that a 25-basis-point increase in the predicted FFTar is, on average, associated with a 0.164% increase in outflows during a four-day window before FOMC meetings. This effect size is one-third of the outflow–ΔFFTar sensitivity estimated using monthly data. In other words, our proposed mechanism can explain at least one-third of the observed monthly relationship between outflows and increases in FFTar.[5] Moreover, the effect size for high-staleness funds is significantly larger: a 0.216% outflow within a four-day window preceding FOMC meetings in response to a 25-basis-point increase in the predicted FFTar. This effect is comparable to the 0.3% weekly outflows observed in bond funds during the COVID-19 period, as documented by Falato et al. (2021).

Besides profiting from the overpriced fund shares, redeeming investors also impose costs on staying investors when fund managers liquidate assets at a cost to meet redemption demands. The liquidation cost of assets, or market illiquidity, thus intensifies the redemption externalities and has been shown to exacerbate outflows when funds underperform (Chen et al., 2010; Goldstein et al., 2017). In our analyses, we also find that illiquidity strengthens the outflow–ΔFFTar sensitivity.

While both staleness in NAVs and illiquidity strengthen our proposed mechanism, do they interact, and if so, how? In terms of policy implications, is it always a good idea to reduce staleness? Also, under what monetary policy environment is the mechanism more relevant? To answer these questions, we build a model of strategic redemption by fund investors in the face of an uncertain interest rate policy. In the model, upon receiving signals regarding the future interest rate, fund investors update their beliefs about the intrinsic values of bond funds and choose between redeeming the fund shares at the NAV and staying in the fund. In equilibrium, investors redeem when the ratio of NAV to the intrinsic fund value exceeds a certain threshold. The likelihood of such an event represents the notion of fund fragility and is empirically proxied by the outflow–ΔFFTar sensitivity. The model yields two additional hypotheses which, to the best of our knowledge, are novel in the literature. We find strong empirical support for both hypotheses.

The first novel hypothesis is that staleness in NAV weakens (strengthens) the outflow–ΔFFTar sensitivity when liquidity is low (high). That is, surprisingly, staleness could stabilize outflows in times of market distress. We illustrate the intuition with an example. Suppose initially there is no mispricing in fund shares. Upon arrival of news, the intrinsic fund value changes by a certain amount while the immediate adjustment of NAV is half of that amount due to staleness. Consider first the scenario with high liquidity. In this case, investors are not concerned about others' redemption and behave more like arbitrageurs. Their equilibrium strategy is to redeem when the shares are overpriced by, say, \$2 or more. Overpricing of \$2 occurs when the news moves the intrinsic fund value down by \$4 and the NAV drops by \$2 (half of \$4). As, by definition, NAV with higher staleness drops even less, the fund shares are *more overpriced*, triggering more outflows. In the scenario with low liquidity, investors are so concerned with the costs imposed by others' redemption that in equilibrium, they redeem even when the shares are underpriced by, say \$2.[6] Underpricing of \$2 occurs when the news moves the intrinsic fund value up by \$4 and the NAV thus increases by \$2. As NAV with higher staleness increases even less, the fund shares are *more underpriced*, reducing investors' incentives to redeem. Therefore, staleness acts as a *stabilizing* force during periods of distress. Empirical tests support this prediction: high-staleness funds experience *similar or less* outflows compared to low-staleness funds in the context of illiquid funds or illiquid market conditions. These findings can explain why fund managers, who exercise some discretion over the determination of NAVs, might want to keep some staleness in NAVs.

The second novel hypothesis is that the outflow–ΔFFTar sensitivity is weaker (stronger) in a low-interest-rate environment when liquidity is low (high). Using the example discussed above, when liquidity is high, investors act like arbitrageurs, and overpricing in NAVs induces outflows. When liquidity is low, investors are predisposed to redeem and are only stopped by enough underpricing in the NAVs. Since a

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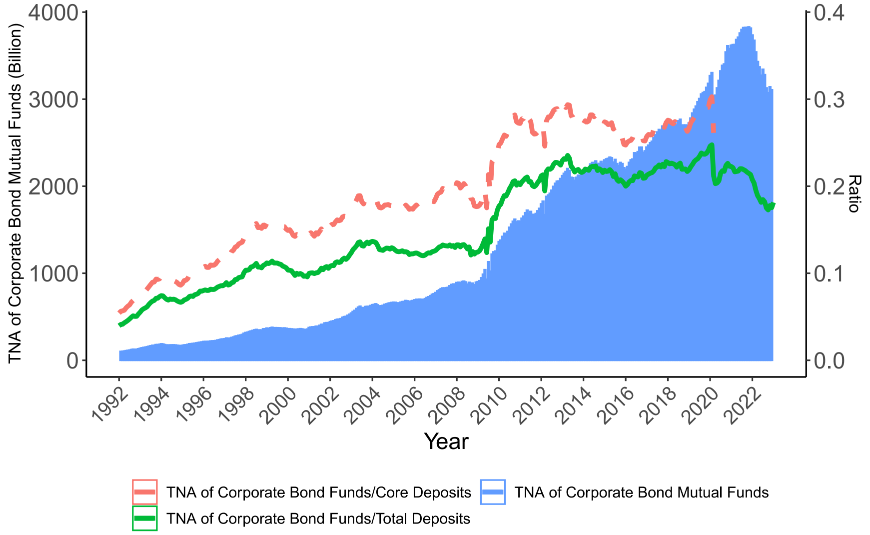
[3] NAVs of corporate bonds mutual funds are stale likely because their daily calculations are based on transaction prices of the portfolio bonds, which might not reflect recent news since most bonds are traded less than once a day. For example, Friewald et al. (2012) show that from October 2004 to December 2008, the mean trading interval of corporate bonds is 4.46 days. The 5th percentile is 1.5 days.

[4] In a similar spirit to Choi et al. (2022), we proxy staleness by the proportion of trading days with non-moving NAVs. The sample average of staleness for corporate bond funds is 31.3%, while the sample average of staleness for equity funds is 4.5%.

[5] It is important to note that this effect size does not capture the full impact of our mechanism. As shown in Table 5, the mispricing of staler funds persists for at least five days after the FOMC meetings. If we consider the 10-day window where mispricing is present, then a 25-basis-point increase in the predicted FFTar is, on average, associated with a 0.428% increase in outflows (see Table IA.3).

[6] More precisely, investors' equilibrium strategy is to redeem when the shares are underpriced by \$2 or less.

(A) Total net asset



(B) Annual flow

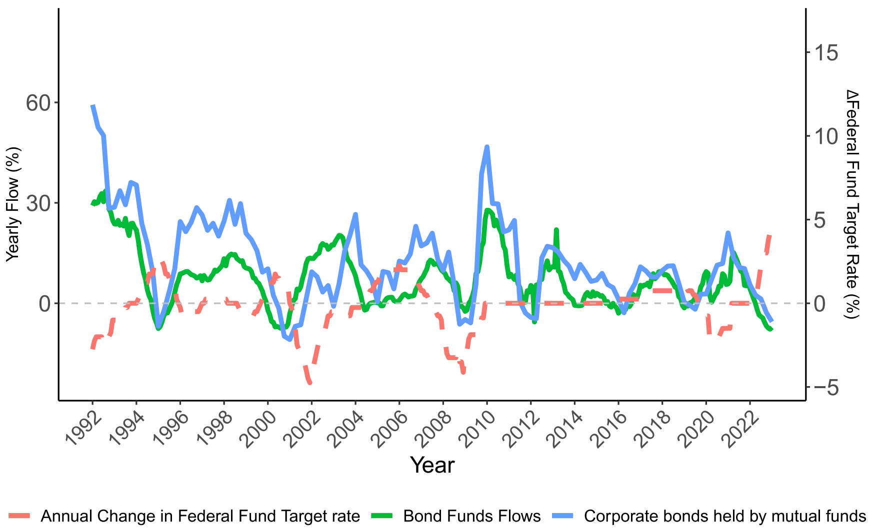


Fig. 1. Total net assets and flows of corporate bond mutual funds. The bar chart in Panel A represents the total net assets (TNA) of corporate bond mutual funds from January 1992 to June 2023. The data is sourced from the CRSP mutual fund database and excludes exchange-traded funds and exchange-traded notes. The line plot on the right y-axis illustrates the ratio of the TNA of corporate bond mutual funds to the total deposits (green line) and the core deposits (red line), sourced from the FRED database. Core deposits comprise small time, saving, demand, and other checkable deposits (the red line stops in April 2020 due to the discontinuation of saving series SVGCBNS in the FRED database). In Panel B, the green line represents the annual flows as a percentage of the TNA of corporate bond mutual funds. The blue line shows the annual change in mutual funds' holdings of corporate and foreign bonds, constructed using BOGZ1LM653063005Q and BOGZ1FA653063005Q in the FRED database. The red line and right y-axis display the annual change in the Federal Funds Target rate. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

low-interest rate environment enhances bond duration and thus potential mispricing in NAVs, it encourages (discourages) outflows when liquidity is high (low). Consistent with this hypothesis, we find a strong outflow–ΔFFTar sensitivity in months characterized by accommodative monetary policy and liquid market conditions. However, during stressed periods or for illiquid funds, capital flows out from funds more aggressively in response to FFTar increases when monetary policy is tight.

Taking stock of the results, our paper highlights a *monetary policy-induced fragility* in corporate bond mutual funds due to their stale NAVs. We have argued that our proposed mechanism carries economically sizeable effects. In terms of policy implications, there are two novel messages. First, policies that aim to reduce staleness in NAVs could backfire and lead to *more* fragility during market distress. More generally, our results highlight the importance of distinguishing between staleness and market illiquidity and of studying their interaction. Second, when increasing interest rates, policymakers should also consider the potential destabilizing effect on corporate bond funds, especially during market distress in a tight monetary policy regime.

Related Literature. Our paper belongs to the literature on the fragility of open-end mutual funds. Chen et al. (2010) use a model to show that redemption leads to asset liquidation and that the associated cost is borne by remaining investors. Thus, redemption externalities lead to a first-mover advantage in investors' redemption decisions, resulting in large outflows in response to poor fund performance. Chen et al. (2010) and Goldstein et al. (2017) empirically find such outflow-to-poor-performance sensitivity in equity and corporate bond funds and, consistent with the theory, the sensitivity is exacerbated by asset illiquidity.[7] In addition, Choi et al. (2022) show that stale pricing in corporate bond funds' NAVs can also intensify the flow-performance sensitivity. While prior research focuses on performance-induced fragility at the individual fund level, our paper contributes to this literature by showing that monetary policy combined with stale pricing is a source of *aggregate* fund fragility. Our paper also finds that staleness *reduces* fragility when liquidity is low, highlighting a novel stabilizing effect of staleness.

Feroli et al. (2014), Banegas et al. (2016), and more recently, Fang (2022) have documented the relationship between monetary policy and corporate bond fund flows. Our contributions relative to this literature are two-fold. First, we provide a theoretical model of the mechanism based on stale pricing of NAVs which allows us to make novel predictions about the situations in which the mechanism will be strongest. Second, with daily and monthly data, our empirical analysis tightly identifies the mechanism, shows that our mechanism can explain a substantial part of the observed outflow–ΔFFTar sensitivity, and supports the model predictions.

Our paper also contributes to the recent growing literature on the destabilizing effects of monetary policy on financial intermediaries. Adrian and Liang (2018) provide a survey. Adrian and Shin (2008) and Drechsler et al. (2018) show that an accommodative monetary policy allows intermediaries to take higher leverage, pushing up asset prices. Di Maggio and Kacperczyk (2017), Choi and Kronlund (2018) and Ivashina and Becker (2015) document reaching-for-yield behaviour of money market funds, corporate bond mutual funds, and insurance companies respectively.[8] Our paper emphasizes a mispricing mechanism specific to corporate bond funds and shows that under both tight and loose monetary policy environments, increases in the policy rate could lead to fragility. Overall, we highlight another unintended consequence of monetary policy.

Lastly, our paper contributes to the extensive literature on the impact of monetary policy on financial markets. Most of the literature emphasizes how news revealed on FOMC meeting dates, measured by unanticipated rate changes, affect asset prices such as treasury prices (Kuttner, 2001) and equity prices (Bernanke and Kuttner, 2005). We complement these results and enrich the understanding of monetary policy transmission by demonstrating that when the rate changes become anticipated by the market days prior to the FOMC meetings, monetary policy changes start to affect flows in corporate bond mutual funds, primarily due to the stale pricing of NAVs.

2. Monetary policy changes and flows to corporate bond mutual funds

In this section, we begin by presenting a strong correlation between monetary policy changes and flows to corporate bond mutual funds. We then provide evidence to support our mispricing channel, which suggests that stale pricing of fund shares around FOMC meetings play a significant role in explaining the observed relationship between interest rates and fund outflows.

2.1. Data

The target federal funds rate (FFTar) set by the U.S. Federal Reserve is downloaded from the Federal Reserve Economic Data (FRED).[9] We also download the dates of FOMC meetings from the Federal Reserve. The daily data for the 30-day Federal Funds Futures is obtained from the Chicago Mercantile Exchange (CME) Group, and the data for the 30-day Eurodollar Futures is extracted from Bloomberg and the FRED database.[10] The data pertaining to corporate bond mutual funds are sourced from two databases, the Center for Research in Security Prices (CRSP) Survivor-Bias-Free U.S. Mutual Fund database, and the Morningstar Direct database.

Our study begins by utilizing the CRSP mutual fund database, as outlined in Goldstein et al. (2017), to generate a comprehensive sample of corporate bond mutual funds.[11] We identify corporate bond mutual funds based on their objective codes provided by CRSP, and apply filters to enhance data quality.[12] Our analysis focuses on the fund shares and encompasses detailed fund characteristics, such as expense ratio, maturity, percentage of cash and government bond holding, and a high-yield fund indicator.[13] We also obtain the daily NAVs of the fund shares from the CRSP mutual funds database, which is used to calculate daily fund returns.

To obtain daily flow information at the fund-share level, we merge the Morningstar Direct and CRSP databases using ticker information, as described in Berk and Van Binsbergen (2015).[14] Morningstar began collecting self-reported total net assets (TNAs) from funds in July 2007. However, daily TNAs are reported at the discretion of the funds, leading to inconsistency in reporting frequency. For example, as pointed out by Zitzewitz (2003), Greene and Hodges (2002), Goetzmann et al. (2001) and Choi et al. (2022), some funds report daily TNAs including same-day flows, while others report pre-same-day flow TNAs. To mitigate the potential errors resulting from inconsistent reporting, our analysis employs cumulative flows in a window of at least five days around FOMC meetings. Our final sample spans from January 2009 to June 2023, and contains 3182 unique fund shares.[15]

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[7] Schmidt et al. (2016) document similar run dynamics in money market mutual funds during the financial crisis in 2008. Jin et al. (2022) use U.K. corporate bond fund data to show that swing pricing can mitigate the first-mover advantage and outflows during market distress.

[8] Cetorelli et al. (2022) find that monetary policy surprises affect flows in loan funds.

[9] Before 2008, the FFTar series, DFEDTAR of FRED, is used. After 2008, a target rate corridor is introduced, we average the upper limit, DFEDTARU, and lower limit, DFEDTARU, as the FFTar.

[10] Eurodollar Future data in Bloomberg started from 2006-01-17, and the data before that is extracted from the FRED database.

[11] Our sample thus excludes corporate bond ETFs which, as discussed in Section 2.4, have distinctly different redemption procedures and trading incentives that put them outside the scope of our model and empirical analysis.

[12] A mutual fund share is considered as a corporate bond fund share if (1) its Lipper objective code in the set ('A', 'BBB', 'HY', 'SII', 'SID', 'IID'), or (2) its Strategic Insight Objective code in the set ('CGN','CHQ','CHY','CIM','CMQ','CPR','CSM'), or (3) its Wiesenberger objective code in the set ('CBD','CHY'), or (4) its CRSP objective code starts with 'IC'. In addition, we limit our sample to fund shares with at least one-year history in the sample period. We also eliminate fund share-month entries without return or total net asset (TNA) information, as well as entries with a TNA increase or decrease of more than 100% over a month. Additionally, we exclude exchange-traded funds and exchange-traded notes from our analysis. Data on corporate bond mutual funds is limited prior to 1991 and thus excluded from our analysis. Additionally, we calculate the performance of each bond fund share using one year of data, and hence the final data spans from January 1992 to June 2023.

[13] A mutual fund share is considered as a high-yield fund share if (1) its Lipper objective code is 'HY' or 'HM', or (2) its Strategic Insight Objective code is 'CHY', or (3) its Wiesenberger objective code is 'CHY', or (4) its CRSP objective code is 'ICQY'.

[14] We keep only bond fund shares that appear in the corporate bond fund sample constructed using the CRSP database and have consecutive daily flows to construct cumulative flows around FOMC meetings.

[15] There are less than 80 funds shares left before July 2008. The fund shares increased to 1500 in July 2008 and kept increasing afterward. To ensure sufficient data coverage and reliability, we keep the sample from January 2009.

Table 1
The payoff of investors at T_2.

	$\lambda \leq \frac{\mathcal{L}p_1}{s\bar{p}_1+(1-s)p_1}$	$\lambda > \frac{\mathcal{L}p_1}{s\bar{p}_1+(1-s)p_1}$
Redeem	$\frac{\text{NAV}}{p_1}$	$\frac{\mathcal{L}p_1}{p_0\lambda} \times \frac{1}{p_1}$
Stay	$\frac{1}{1-\lambda} \times \left(\frac{1}{p_0} - \frac{\lambda\text{NAV}}{\mathcal{L}p_1}\right) + \frac{\psi}{p_0}$	0

Table 2 provides summary statistics for daily data in Panel A and monthly data in Panel B. The tables show that capital flows into corporate bond mutual funds during both sample periods, with an average daily inflow of 0.03% of TNA between 2009 and 2023 and an average monthly inflow of 0.73% from 1992 to 2023. Although the sample periods differ, the two magnitudes are largely consistent. Additionally, corporate bond mutual funds generate positive returns, with an average return of roughly 0.3% per month for both daily and monthly samples. The other reported statistics at the monthly level are consistent with Table 1 in Goldstein et al. (2017).

2.2. Aggregate facts

In this section, we document a strong correlation between monetary policy changes and flows to corporate bond funds, and draw comparisons with the impact of monetary policy on the banking sector.

Panel B of Fig. 1 displays the annual change in the Federal Fund Target rate represented by the green line, alongside the flows to corporate bond funds in red. The plot depicts a pattern whereby corporate bond funds tend to experience significant outflows (inflows) during periods of monetary tightening (easing) in the past 30 years. The blue line of Panel B plots the annual change in mutual funds' holdings of corporate bonds issued by non-financial corporate businesses. These holdings exhibit a strong comovement with the flows to corporate bond mutual funds. This comovement suggests that the effects of monetary policy can be transmitted through corporate bond mutual funds, impacting not only the bond funds themselves but credit availability in the real economy (see also Fang (2022)).

To evaluate the economic significance of corporate bond fund flow sensitivity to monetary policy, we compare it with the deposit flow sensitivity to monetary policy documented by Drechsler et al. (2017). We regress annual (or monthly) outflows from corporate bond mutual funds and, respectively, deposit withdrawals from all commercial banks on FFTar changes. Following Drechsler et al. (2017), we consider the withdrawals of both total deposits and core deposits, which include small time, demand, and other checkable deposits. In addition, we include several macroeconomic variables as controls, such as changes in the term structure of interest rates (measured by the difference in yield between 30-year and 1-year Treasury bonds), changes in default risk (measured by the difference in yield between BBB- and AAA-rated corporate bonds), and changes in bond market illiquidity (approximated by changes in the VIX index), all extracted from FRED. The sample spans from January 1992 to June 2023 and the regression specification is as follows:

$$\text{Annual Outflow}_t = \Delta\text{FFTar}_t + \text{Controls} + \varepsilon_t. \tag{1}$$

We find that flows in corporate bond funds are more responsive to increases in FFTar than deposit flows. The results of the regression analysis are presented in Table 3. The first three columns focus on annual flows: a 25-basis-point increase in FFTar is associated with a 1.22% annual outflow from corporate bond mutual funds, which is more than twice as large as the effect observed for core deposits in commercial banks.[16] The monthly results are even more pronounced, with a 25-basis-point increase in FFTar associated with a 0.319% monthly outflow from corporate bond mutual funds as shown in column 4, corresponding to an annual flow of 3.828%. Given that the TNA of corporate bond funds have grown to approximately one-third of total deposits in commercial banks, these findings underscore the economic significance of corporate bond funds in monetary policy transmission.

2.3. Mechanism

To explain the outflow–ΔFFTar relationship in corporate bond funds, we propose a mechanism that relies on three premises. First,

Table 2
Summary statistics of fund characteristics. The table provides a summary of the characteristics of corporate bond mutual funds, utilizing data from CSRP and Morningstar. The daily data spans from January 2009 to June 2023, covering 3182 funds, while the monthly data encompasses January 1992 to June 2023 and includes 6251 unique fund share classes across 2447 distinct funds. "OutFlows" is the fund outflows in a given month or a given period around FOMC meetings in percentage points. Monthly (Daily) return is the monthly (daily) net fund return in percentage points. The table includes the following characteristics: "TNA" indicates the total net assets of the funds, "Age" represents the number of years since the fund's inception as recorded in the CRSP database, "Expense" denotes the fund's expense ratio, expressed in percentage points, "Cash Holdings" reflects the proportion of fund assets held in cash, presented as a percentage, "Government Bond Holding" represents the proportion of fund assets invested in government bonds, also expressed as a percentage and "Maturity" indicates the weighted average maturity of the fund's investments, measured in years. Perf, η_B, η_M are coefficients from regression (11) for each fund share. Exchange-traded funds and exchange-traded notes have been excluded from the analysis using the CRSP mutual fund database. To address the impact of outliers, all continuous variables have been winsorized at the 1% quantile from each tail.

Panel A: Daily data (January 2009 to June 2023)								
	N	Mean	Std Dev	P5	P25	Median	P75	P95
OutFlows (%)	7,785,862	−0.033	0.422	−0.531	−0.089	−0.003	0.065	0.360
Daily return (%)	8,282,198	0.014	0.246	−0.385	−0.096	0.000	0.107	0.411
$\text{OutFlows}_{(-5,-1]}$ (%)	168,019	−0.155	1.558	−2.338	−0.435	−0.026	0.269	1.578
$\text{OutFlows}_{(-1,5]}$ (%)	168,047	−0.293	2.319	−3.595	−0.770	−0.098	0.396	2.429
$\text{OutFlows}_{(5,15]}$ (%)	166,113	−0.389	2.839	−4.581	−0.976	−0.099	0.542	2.935

Panel B: Monthly data (January 1992 to June 2023)								
	N	Mean	Std Dev	P5	P25	Median	P75	P95
Monthly outflows (%)	745,930	−0.727	8.038	−12.708	−1.690	0.175	1.631	7.610
Monthly return (%)	745,930	0.319	1.461	−2.171	−0.250	0.315	1.013	2.582
TNA (million)	745,930	461.412	1361.585	0.200	8.300	54.100	263.700	2153.955
Age (years)	745,930	10.022	8.667	0.992	3.671	7.740	14.159	25.997
Expense (%)	615,256	0.975	0.491	0.320	0.610	0.860	1.300	1.870
Cash holding (%)	660,539	2.582	11.409	−14.070	0.000	1.880	4.840	18.220
Government bond holding (%)	660,539	13.100	17.443	0.000	0.000	4.060	22.210	49.040
Maturity (years)	490,966	10.044	5.523	2.900	6.300	9.200	13.200	18.400
Perf (%)	672,415	−0.021	0.356	−0.579	−0.143	−0.029	0.083	0.579
η_B	672,415	0.634	0.478	−0.058	0.271	0.678	0.960	1.320
η_M	672,415	0.131	0.164	−0.022	0.012	0.064	0.210	0.486

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[16] Throughout the paper, we assess the impact to a 25-basis-point increase in FFTar. The effect size reported in column 1 of Table 3 is 4.878% divided by 4, resulting in 1.220%.

Table 3

Monetary policy and outflows from corporate bond mutual funds and banks. The table displays time series regressions of aggregate outflows from corporate bond mutual funds and banks in relation to FFTar changes. The data spans from January 1992 to June 2023. The first three columns present annual outflows, while the last three columns show monthly outflows. All values are expressed as a percentage of the size of aggregate corporate bond mutual funds (columns 1 and 4), commercial bank deposits (columns 2 and 5), and core deposits (columns 3 and 6). Core deposits comprise small time, saving, demand, and other checkable deposits (the sample stops in April 2020 due to the discontinuation of saving series SVGCBNS in the FRED database). ΔFFTar indicates the percentage point changes in the FFTar rate and shares the same construction window as the dependent variable. Additional macro control variables include the change in the Baa-Aaa Spread, the change in the spread between the 30-year and 1-year treasury yields, and the logarithmic change in the VIX index. These variables also have the same construction window as the dependent variable. "COVID" is an indicator variable with a value of 1 for the year 2020 in the annual regression and for March 2020 in the monthly regression, and 0 otherwise. Coefficients (standard errors) are reported in shaded (unshaded) rows. Standard errors in brackets are computed with Newey–West standard errors with 12 lags. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	Annual outflows (%)			Monthly outflows (%)		
	Bond funds (1)	Deposits (2)	Core deposits (3)	Bond funds (4)	Deposits (5)	Core deposits (6)
ΔFFTar	4.878^{***}	0.688	1.918^{**}	1.276^{***}	0.676^{***}	0.712^{*}
	(1.384)	(0.829)	(0.741)	(0.380)	(0.224)	(0.413)
ΔBaa-Aaa spread	9.208^{***}	0.582	−0.066	2.766^{***}	0.564	-1.388^{***}
	(1.566)	(0.993)	(0.903)	(0.492)	(0.516)	(0.371)
Δ30Y-1Y spread	2.055	−0.188	0.877	0.209	−0.002	−0.283
	(1.605)	(0.939)	(0.824)	(0.434)	(0.174)	(0.260)
$\Delta\log(\text{VIX})$	−0.481	−0.334	1.460^{*}	−0.179	0.001	0.310^{*}
	(1.348)	(1.022)	(0.779)	(0.334)	(0.223)	(0.182)
COVID	7.686^{***}	-10.106^{***}	−1.082	4.247^{***}	-4.922^{***}	-1.700^{**}
	(2.036)	(2.207)	(1.211)	(0.787)	(0.540)	(0.746)
Constant	-6.891^{***}	-6.234^{***}	-6.370^{***}	-0.507^{***}	-0.508^{***}	-0.534^{***}
	(0.978)	(0.499)	(0.435)	(0.092)	(0.047)	(0.044)
Observations	378	378	339	378	378	339
Adjusted R^2	0.439	0.332	0.272	0.126	0.131	0.156

there is new information about the future FFTar revealed to the market days prior to FOMC meetings. Second, the NAVs of corporate bond funds are stale. Third, as stale NAVs do not fully respond to new market information, future changes in NAVs around FOMC meetings are predictable. The mechanism then works as follows: When investors anticipate an impending increase (decrease) in the FFTar, they withdraw (deposit) capital from (to) corporate bond funds around FOMC meetings in order to profit from the temporary mispricing of fund shares due to stale pricing. As a result, fund outflows around FOMC meetings and changes in the FFTar are positively correlated.

Below, we first present empirical evidence supporting these three premises. Then, we show evidence consistent with strategic redemption by fund investors. Finally, we discuss the robustness of our findings to various alternative hypotheses.

2.3.1. NAV mispricing around FOMC meetings

Premise 1: Changes in FFTar are predictable. We follow Cochrane and Piazzesi (2002) and examine the predictive power of market-traded derivatives on FFTar in forecasting changes during forthcoming FOMC meetings. Specifically, we study the Federal Funds Futures and the Eurodollar Futures and we employ the following predictive regression model:

$$\Delta FFTar_{[-1,1]} = \Delta \text{Futures}_{(\tau+5,-1]} + \varepsilon_t, \tag{2}$$

where $\Delta FFTar_{[-1,1]}$ represents the change in FFTar announced at each FOMC meeting (date 0). We examine the changes in the Future rates that occur between meetings within a window of $(\tau+5,-1]$, where τ refers to the date of the preceding meeting. We choose the window $(\tau+5,-1]$ instead of $(\tau,-1]$ to allow the Futures to respond to the news revealed in the preceding FOMC meeting.

The regression results are presented in Table 4. ΔFFuture and ΔEurodollar denote changes in the Fed Funds Future rates and the Eurodollar Future rates, respectively. The positive and significant coefficients indicate that the Future rate changes before the meetings have strong predictive power, both in the full sample and in the subsample after the financial crisis. In the full sample, both market-traded derivatives are able to explain over 30% of the variations in future FFTar changes, consistent with results in Krueger and Kuttner (1996) and Gürkaynak et al. (2007). Furthermore, they accurately predicted the direction of FFTar changes in 69 out of 80 meetings where actual changes in FFTar occurred. These findings are visually represented in Figure IA.1, which displays the paired dots representing the Future rate changes and FFTar changes.

In the period following the financial crisis, the Eurodollar Future rates demonstrate exceptional predictive power for future FFTar changes, with an R^2 value of 52.1%. In addition, the predicted changes closely align with the actual changes, with a 25-basis-point increase in Eurodollar Future rates preceding the meeting corresponding to a 22-basis-point increase in the announced FFTar. We also note that 23 out of 24 meetings with announced FFTar changes are correctly predicted. These findings are consistent with the notion that central banks have increasingly utilized public communications to shape market expectations regarding future policy actions, as emphasized in prior research (Blinder et al., 2008; Bernanke, 2010). The evidence supports our premise that the prices of traded derivatives reveal new information about future FFTar before FOMC meetings. Given the stronger predictive power observed in the Eurodollar Futures after 2009, our subsequent analysis will rely on the prices of this contract.

Premise 2: NAVs of corporate bond funds are stale. Next, we present evidence that the NAVs of some corporate bond funds do not fully react to the information revealed by market derivatives before FOMC meetings. NAVs are likely to be stale because their daily calculations are based on transaction prices of the corporate bonds the funds hold. These transaction prices might not reflect recent news since most bonds are traded less than once a day. Choi et al. (2022) find significant autocorrelation in returns of bond funds, consistent with the staleness hypothesis.[17]

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[17] Variation in staleness in fund pricing likely comes from a combination of the differences in underlying asset holdings and the variation in NAV adjustment strategies across funds. As corporate bonds are traded infrequently, their fair values could not be inferred directly from transaction prices and have to be estimated. The SEC guidance comes from the adoption of Rule 2a-4, which states that market values should be used where available and that otherwise, assets "shall be valued at fair value as determined in good faith by the board of directors of the registered company". This leaves some discretion in terms of valuation practices to funds and their managers. As noted in Choi et al. (2022), some managers rely on the latest transaction prices of the underlying, which would lead to staleness in fund share prices, while others outsource the pricing to third-party service providers.

Table 4

Predictive regressions for federal fund target rate changes. The table presents the results of predictive regressions to predict FFTar changes within a window of [−1, 1] around FOMC meetings, using market data prior to the meetings. The predictor variable is changes in rates for the Federal Funds Futures (columns 1 and 3) and Eurodollar Futures (columns 2 and 4) within the (τ+5, −1] window. Here, τ represents the date of the preceding FOMC meeting. The analysis employs two different sample windows: January 1992 to June 2023 and January 2009 to June 2023. Coefficients (standard errors) are reported in shaded (unshaded) rows. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	$\Delta FFTar_{[-1,1]}$			
	Year ≥ 1992		Year ≥ 2009	
	(1)	(2)	(3)	(4)
ΔFFuture$_{(\tau+5,-1]}$	0.643***		0.501***	
	(0.056)		(0.065)	
ΔEuroDollar$_{(\tau+5,-1]}$		0.687***		0.886***
		(0.053)		(0.076)
Constant	0.003	−0.003	0.018	0.014
	(0.011)	(0.010)	(0.015)	(0.012)
Observations	281	281	125	125
Adjusted R^2	0.320	0.372	0.323	0.521

Table 5

NAV changes around FOMC meetings. This table compares the responsiveness of fund NAVs to market information on monetary policy changes around FOMC meetings, separately for high-staleness funds to low-staleness funds (which we refer to as High-stale and Low-stale to conserve space). The dependent variables are the logarithmic changes in NAV for each fund share i within four different time windows around FOMC meetings: (τ+5,−5], (−5,−1], (−1,5], and (5,15], with 0 representing the date of the FOMC meeting, and τ indicating the date of the previous FOMC meeting. For each time window, the information revealed by the Eurodollar Future rates are measured within the respective windows. Funds that exhibit a higher (lower) proportion of non-moving NAV days in the non-FOMC window leading up to the preceding FOMC meeting, compared to the median, are classified as high-(low-)staleness funds. We include one-year lagged fund characteristics, such as the total net asset in log scale, expense ratios, percentage of cash and government bond holdings, outflows from the past five days, and high-yield fund indicator, as controls, denoted as Controls$^F_{i,t-1}$. To account for the COVID-19 pandemic, we include an indicator variable that is equal to one for the FOMC meeting on March 3, 2020, and zero otherwise. Each observation is weighted by the previous year's end-of-year fund TNA. Standard errors are clustered at each FOMC meeting and the fund share level. Coefficients (standard errors) are reported in shaded (unshaded) rows. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	ΔNAV$_{i,(\tau+5,-5]}$		ΔNAV$_{i,(-5,-1]}$		ΔNAV$_{i,(-1,5]}$		ΔNAV$_{i,(5,15]}$	
	High-stale (1)	Low-stale (2)	High-stale (3)	Low-stale (4)	High-stale (5)	Low-stale (6)	High-stale (7)	Low-stale (8)
ΔEurodollar$_{(\tau+5,-5]}$	−1.683***	−3.744**	−0.687**	−0.912				
	(0.591)	(1.490)	(0.296)	(0.559)				
ΔEurodollar$_{(\tau+5,-1]}$					−0.741***	−0.732		
					(0.213)	(0.508)		
ΔEurodollar$_{(\tau+5,5]}$							0.137	−0.467
							(0.290)	(0.365)
Controls$^F_{i,t-1}$	✓	✓	✓	✓	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	80,229	98,669	80,227	98,665	83,144	102,380	83,151	102,431
Adjusted R^2	0.140	0.189	0.090	0.067	0.096	0.021	0.085	0.078

We proxy the staleness of bond fund NAVs with the proportion of days in which the NAV does not change in the period leading up to each FOMC meeting. This measure is obtained by dividing the number of trading days in which NAVs do not change from the previous trading day by the total number of trading days between $(\tau+5,-1]$, where τ represents the date of the preceding FOMC meeting.[18] Fig. 2 plots the distributions of the staleness measures for corporate bond and equity funds. The plots clearly show that corporate bond funds have much higher staleness than equity funds. On average, the staleness measure for corporate bond funds is 0.31, implying that their NAVs do not move in 31% of the days preceding FOMC meetings. In all the analyses, we use a one-meeting lag of the staleness measure to mitigate concerns about overlapping the measurement and the estimation windows. We classify funds with a higher (lower) proportion of non-moving NAV days than the median in the non-FOMC window before the preceding FOMC meeting as high- (low-)staleness funds. In Table IA.1, we observe that high-staleness funds have lower average holdings of cash and government bonds, a shorter maturity, and a lower likelihood of being high-yield funds compared to low-staleness funds. However, there are no significant differences between high-staleness and low-staleness funds in terms of fund size, and the likelihood of being primarily held by institutional investors.

Premise 3: Changes in NAVs are predictable. If NAVs are stale and thus do not incorporate public information promptly, changes in Eurodollar Futures, which as argued above contain information about future changes in FFTar, should predict future changes in NAV. We test this conjecture with the following predictive regression:

$$\Delta NAV_{i,(t_1,t_2]} = \Delta\text{Eurodollar}_{(\tau+5,t_1]} + \text{Controls}^F_{i,t-1} + \alpha_i + \varepsilon_{i,d}, \qquad (3)$$

where $\Delta NAV_{i,(t_1,t_2]}$ represents the logarithmic changes in the NAV of fund share i within the time windows $(t_1,t_2]$ surrounding FOMC meetings. The analysis examines the changes in NAVs within four distinct time windows surrounding FOMC meetings: (τ+5,−5], (−5,−1], (−1,5], and (5,15]. These time windows are carefully chosen to ensure there is no overlap with preceding or subsequent FOMC meetings.

Moreover, we include fund share fixed effects denoted by α_i. We also incorporate control variables denoted as Controls$^F_{i,t-1}$, which are the lagged fund characteristics from one year prior, including the logarithm of total net assets, expense ratios, the percentage of cash and government bond holdings, fund flows in the preceding five days, and an indicator variable for high-yield funds. To account for the COVID-19 pandemic, we also add a "COVID" indicator, set to 1 for the FOMC meeting on March 3, 2020, and 0 otherwise. The inclusion of these control variables addresses concerns that the results may be driven by

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[18] In untabulated robustness tests, we also construct an alternative measure of staleness following Choi et al. (2022), which is calculated as the sum of the coefficients on the first five lagged daily returns from rolling three-month fund-by-fund regressions of an AR(5) model, updated each month. The results are robust using this alternative measurement.

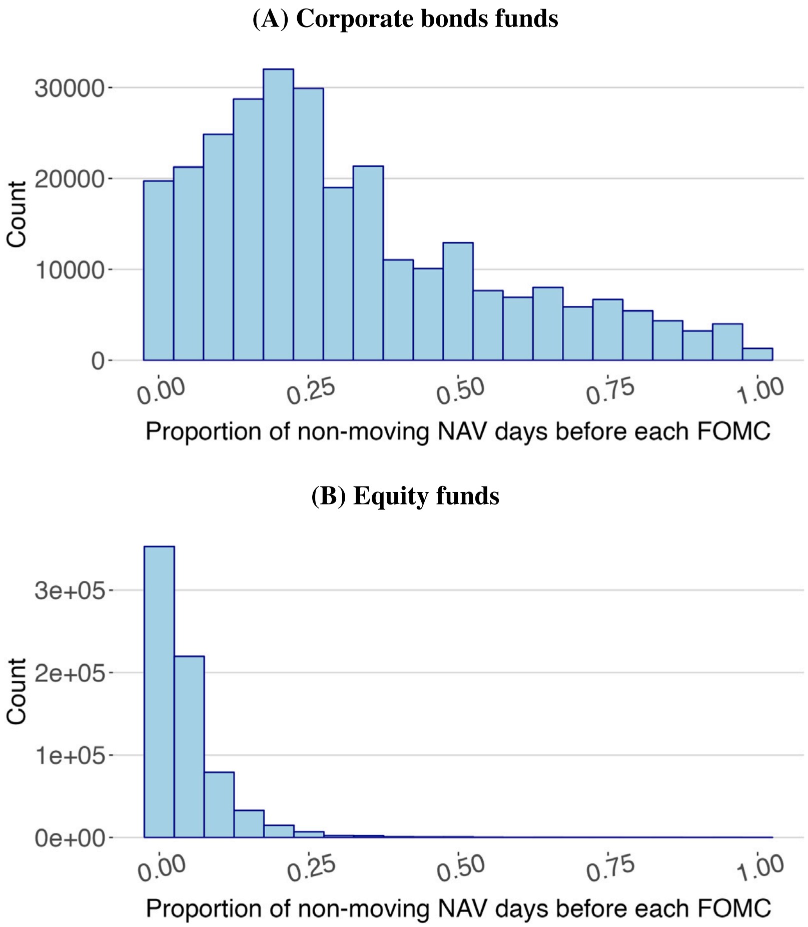

Fig. 2. Staleness of corporate bond and equity funds. Figures plot the proportion of non-moving NAV days before FOMC meetings for corporate bonds funds (Panel A) and equity funds (Panel B). This measure is obtained by counting the number of trading days where NAVs do not exhibit any change from the previous trading day and dividing it by the total number of trading days between $(\tau+5,-1]$, where τ represents the date of the preceding FOMC meeting. The sample includes all FOMC meetings from January 2009 to June 2023.

factors other than the staleness of NAVs. To assess the overall impact on the aggregate bond fund sector, we assign weights to each observation based on the fund's TNA value from the previous year. Standard errors are clustered at both the FOMC meeting and fund share levels to account for potential heteroscedasticity and correlation within these groups.

The regression results are presented in Table 5. Columns 1–2 study the contemporaneous relationship between changes in NAVs and the Eurodollar Futures rate in the window (τ+5,–5] for high and low staleness funds, respectively. The results are intuitive: the NAVs of both high-staleness and low-staleness funds decrease when Eurodollar Future rates increase.

The more important question is whether the information embedded in the Eurodollar Futures can predict future changes in NAVs. The predictive regressions in columns 3–8 show a distinct pattern for high-staleness and low-staleness funds: changes in the NAVs of high-staleness funds are highly predictable from five days before to five days after the meeting (columns 3 and 5) and are no longer predictable in the (5,15) window (column 7). These findings suggest that NAVs of high-staleness funds do not fully incorporate the information revealed in the Eurodollar Futures until five days after the meeting. In contrast, changes in the NAVs of low-staleness funds are not predictable in any of the windows (columns 4, 6, and 8). All of the results above remain robust even when we control for potential information for monetary policy in the longer horizon, proxied by longer-maturity Treasury yields as shown in Table IA.2.

Overall, these findings highlight the delayed and incomplete adjustments observed in high-staleness funds, indicating that their shares are temporarily mispriced, particularly within a 10-day window around FOMC meetings.

2.3.2. *Investor flows in response to NAVs mispricing*

Opportunistic investors could exploit the temporary overpricing (underpricing) by redeeming their shares (depositing funds) before NAVs are fully adjusted. To investigate this phenomenon, we employ the same specification as described in Eq. (3), but with cumulative daily flows as the dependent variable within the time windows of (−5,−1], (−1,5], and (5,15] around FOMC meetings.

The regression results are presented in Table 6. We find that the positive relationship between changes in the Eurodollar rate and outflows is particularly pronounced for high-staleness funds within the 10-day window around FOMC meetings, for which, as argued above, the NAVs have not fully incorporated information about future changes in the FFTar. In terms of magnitude, a 25-basis-point increase in the Eurodollar Future rates is associated with a 0.47% ($= \frac{0.862\%+1.018\%}{4}$) increase in fund outflows for high-staleness funds in the 10-day window surrounding FOMC meetings. This effect is more than double the effect observed for low-staleness funds, which is around 0.20% in the same window. This magnitude is also economically significant, as the 0.47% outflows translate to approximately 14 billion USD when benchmarked to the total size of corporate bond mutual funds in 2023.

The last three columns show that the relationship between outflows and the Eurodollar rate remains significant even 5 days after the FOMC meeting. However, in this window, there is no longer a distinction between high-staleness and low-staleness funds, indicating that the

Table 6

Monetary policy-induced fragility. This table examines how fund flows respond to market information regarding monetary policy changes around FOMC meetings, specifically comparing the responses of high-staleness funds to low-staleness funds (which we refer to as High-stale and Low-stale to conserve space). The dependent variables are the cumulative fund outflows, measured in percentage points, for each fund share i within three different time windows around FOMC meetings: (−5,−1], (−1,5], and (5,15], where 0 represents the date of the FOMC meeting. For each time window, the information revealed by the Eurodollar Future rates is measured within the respective windows (τ+5,−5], (τ+5,−1], and (τ+5,5], where τ indicates the date of the previous FOMC meeting. Funds that exhibit a higher (lower) proportion of non-moving NAV days in the non-FOMC window leading up to the preceding FOMC meeting, compared to the median, are classified as high-(low-)staleness funds. The interaction terms measure the difference in the outflow-rate relationship between high-staleness and low-staleness funds. We include one-year lagged fund characteristics, such as the total net asset in log scale, expense ratios, percentage of cash and government bond holdings, outflows from the past five days, and high-yield fund indicator as controls, denoted as $\text{Controls}^F_{i,t-1}$. To account for the COVID-19 pandemic, we include an indicator variable that is equal to one for the FOMC meeting on March 3, 2020, and zero otherwise. Each observation is weighted by the previous year's end-of-year fund TNA. Standard errors are clustered at each FOMC meeting and the fund share level. Coefficients (standard errors) are reported in shaded (unshaded) rows. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	$\text{OutFlows}_{i,(-5,-1]}$			$\text{OutFlows}_{i,(-1,5]}$			$\text{OutFlows}_{i,(5,15]}$		
	High-stale (1)	Low-stale (2)	All (3)	High-stale (4)	Low-stale (5)	All (6)	High-stale (7)	Low-stale (8)	All (9)
$\Delta\text{Eurodollar}_{(\tau+5,-5]}$	0.862***	0.277***	0.277***						
	(0.135)	(0.097)	(0.097)						
$\Delta\text{Eurodollar}_{(\tau+5,-5]} \times \mathbb{1}(\text{High-stale})$			0.585***						
			(0.142)						
$\Delta\text{Eurodollar}_{(\tau+5,-1]}$				1.018***	0.515***	0.515***			
				(0.359)	(0.133)	(0.133)			
$\Delta\text{Eurodollar}_{(\tau+5,-1]} \times \mathbb{1}(\text{High-stale})$						0.503*			
						(0.289)			
$\Delta\text{Eurodollar}_{(\tau+5,5]}$							0.766***	0.435***	0.435***
							(0.211)	(0.118)	(0.118)
$\Delta\text{Eurodollar}_{(\tau+5,5]} \times \mathbb{1}(\text{High-stale})$									0.331
									(0.226)
$\text{Controls}^F_{i,t-1}$	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	80,262	98,718	178,980	83,133	102,439	185,572	82,632	101,936	184,568
Adjusted R^2	0.217	0.266	0.246	0.262	0.287	0.277	0.231	0.208	0.217

outflows driven by mispricing dissipate within 5 days after the FOMC meeting. This finding aligns with the results presented in Table 5, which show that NAVs fully incorporate information about FFTar changes within the first 5 days following the meetings.

The pronounced outflow–ΔFFTar relationship in the (5, 15] window, a period when changes in NAVs are no longer predictable, implies that outflows do not revert following FOMC meetings. This observation also suggests that our mispricing mechanism alone cannot fully explain the relationship between interest rates and fund outflows. For example, we find that reaching-for-yield behaviour by funds has some explanatory power (see footnote 22). However, we argue that our mechanism accounts for at least one-third of this relationship. Table IA.3 compares the outflow–ΔFFTar sensitivity estimated using daily and monthly data for the same sample. The results show that, on average, a 25-basis-point increase in the anticipated changes in FFTar is associated with a 0.164% increase in outflows during the window (−5, −1], which is one-third of the coefficient size estimated using monthly data (column 6). When considering the outflows in the window (−5, 5], our proposed mechanism explains 90% ($= \frac{1.711}{1.899}$) of the monthly effect.

Sharper Identification. In the previous analysis, we choose a wide window (τ+5,−5] for each FOMC meeting to make the analyses consistent. However, this introduces noise in our estimation because the stale pricing mechanism should begin on the date when the market learns about the impending interest rate changes. In order to sharpen the estimation, we identify this date as the earliest date before each FOMC meeting where the daily change in the Eurodollar Futures exceeds the 95th percentile of the sample.[19] We denote this date as τ' and then estimate the mechanism in the subsequent five days. In our sample, there are 56 FOMC meetings where substantial variations in Eurodollar Futures rates occurred prior to the meetings. In Panel A of Table IA.4, we confirm that changes in the Eurodollar Future rates in the 5 days following τ' (but before FOMC meetings) provide substantial information about future FFTar changes. Using Eurodollar rates to predict target rate changes in column 4, the adjusted R^2 is 60%.

Panels B and C examine the changes in NAVs and outflows for high-staleness and low-staleness funds within the 5-day window subsequent to τ'. Analysing columns 2 and 4 of Panel B reveals a marked contrast in how NAVs respond to information in futures rates: high-staleness funds do not exhibit significant contemporaneous adjustments, whereas low-staleness funds exhibit significant responsiveness. Consequently, investors respond to the mispricing in high-staleness funds by redeeming their shares, leading to outflows nearly double those seen in low-staleness funds. In sum, with this sharp identification in the days of news arrival, the cross-sectional analyses comparing high- and low-staleness funds provide compelling empirical evidence for our proposed mechanism.

2.4. Complementary analyses

Heterogeneous Effects in Sub-Samples. Panel A of Table IA.5 examines the impact of monetary policy changes on fund flows across various subsamples using daily data. To be conservative, we focus on outflows in the (−5, −1] window before FOMC meetings. The first two columns indicate that institution-oriented funds have a weaker outflow–ΔFFTar sensitivity compared to retail-oriented funds. An explanation consistent with our mechanism is that institution-oriented funds are more likely to have concentrated, large owners who internalize more redemption externalities (Goldstein et al., 2017). Columns 3–4

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[19] We document two specific examples of such shocks. In December 2015, the Federal Reserve increased interest rates for the first time after the financial crisis, and this change was widely anticipated. The meeting date is 15th December. A New York Times article on November 18th noted that officials were forgoing usual reticence to warn of potential upcoming changes explicitly. For this particular date we note changes in the futures market on 17th November (nytimes.com). Another example is 15th March 2017 on which the Fed increased the range to 0.75–1.00 from 0.50–0.75. Our methodology identifies 14th February 2017 as a news shock date. On the day after, it was reported that retail sales increased more than expected and CPI had its biggest gain in the preceding four years (reuters.com), which likely drove market expectations of a rate increase.

compare index and non-index bond funds and find that the outflow–ΔFFTar sensitivity is significant only for non-index funds. These results align with our mechanism because it is likely that bonds in the index are traded more frequently and hence that the NAVs of index funds are less stale.

Reaching-for-yield Alternative. Choi and Kronlund (2018) have shown that corporate bond mutual funds tilt their portfolios towards riskier bonds in low-interest rates regimes. They further find that investment-grade funds engage in such "reaching-for-yield" (RFY) behaviour and attract more investor flows.[20] According to this narrative, when interest rates increase, funds do less RFY and this leads to outflows (or, less inflows).

Below we argue that it is unlikely that our mechanism is driven by RFY. First, conceptually, while our mechanism takes place days around FOMC meetings, tilting the weights in a bond portfolio would take weeks (Choi and Kronlund use quarterly bond holdings data). Furthermore, when we conduct a sub-sample analysis in Panel B of Table IA.5 separately for high-yield (HY) and investment-grade (IG) funds, both types of funds experience significant outflows when the FFTar is expected to increase.[21] The effect is stronger for HY funds which suggests a different mechanism from Choi and Kronlund (2018) in which investor flows only respond significantly to RFY by IG funds. Lastly, we show that our results continue to hold after controlling for RFY. We do so in Table IA.7 by including all the variables that Choi and Kronlund have shown to predict RFY behaviour as additional control variables. The outflow–ΔFFTar relationship remains stronger for high-staleness funds, especially before FOMC meetings, validating the robustness of our mechanism.[22]

Monetary Policy Changes or Return Autocorrelations. Choi et al. (2022) show that stale NAVs lead to autocorrelation in fund returns and, consequently, that daily fund flows are positively correlated with predicted returns. We argue that our findings are not solely driven by the predicted returns. Following the methodology of Choi et al. (2022), we construct Return Forecast$_{(\tau+5,t_2]}$, where τ represents the date of the preceding FOMC meeting. This variable represents the predicted 5-day cumulative return based on data from $[\tau+5,t_2]$ and is generated using an autoregressive model. We then incorporate it as a control and show that our results continue to hold (see Table IA.8). This result suggests that return autocorrelations do not fully capture the staleness in NAVs when news about major events such as monetary policy changes arrives.

Flows in Equity and Treasuries Funds. If investors withdraw funds from corporate bond mutual funds when interest rate increases, do they reallocate their funds to other asset classes such as equity or Treasuries? Our analyses of equity and Treasuries funds do not find such portfolio reallocation. We show that increases in Eurodollar Futures do not predict flows in equity funds (Table IA.9) whereas there are some predicted *outflows* for Treasuries funds right after the FOMC meetings (Table IA.10).[23]

Mispricing and Flows in Corporate Bond ETFs. Outflows from open-end corporate bond mutual funds occur when investors redeem the shares at the NAVs. In corporate bond Exchange-Traded Funds (ETFs), however, investors do not cause outflows because they can only trade shares in the secondary market at the prevailing market prices. Only authorized participants (APs) can redeem the shares from the ETF sponsors for the underlying assets, resulting in outflows. The APs tend to buy the shares and redeem them when the market prices are at a discount relative to the NAVs. By doing so, the APs reduce the discount.

Would monetary policy lead to mispricing in NAVs of corporate bond ETFs and affect the creation or redemption of shares by APs? In untabulated results extending our analyses to ETF data, we observe weaker evidence of this mechanism compared to mutual funds. We attribute the weaker results to two factors. First, our staleness proxy indicates that ETF NAVs are less stale than those of mutual funds, potentially due to the different compositions of underlying portfolio bonds. Second, and more importantly, mispriced NAVs in ETFs do not necessarily represent profitable trading opportunities for APs because they transact shares at market prices, not at mispriced NAVs. Similarly, when the APs contact bond dealers to trade a basket of bonds, the bond dealers will update the quotes to incorporate the monetary policy news. In other words, if the market prices are efficient, APs cannot profit from mispriced NAVs. This contrasts sharply with mutual funds, in which investors can buy (redeem) shares at underpriced (overpriced) NAVs directly.

3. Model and hypotheses development

Our mechanism focuses on the fund investors' decision to redeem or to stay in corporate bond funds in the face of uncertain interest rate changes. Two key features of corporate bonds make outflows responsive to interest rate changes. First, the staleness of fund NAVs results in mispricing which can be exploited by investors. Second, the illiquidity of corporate bonds implies that the liquidation of bonds triggered by redemption will be costly. Since the NAV does not reflect this future liquidation cost, investors who stay in the fund will bear the cost, inducing them to redeem in the first place. Below, we develop and analyse a model to capture these strategic considerations by fund investors. In Section 3.3, we list the model's main predictions.

3.1. A model of fund runs induced by monetary policy

There are three dates: T_0, T_1, and T_2. Agents are risk-neutral and consume one storable good "cash" without time-discounting. There is one asset traded in the market, namely, a zero-coupon long-term bond ("the bond") with a face value of \$1 maturing at T_2. We assume the bond has no credit risk so as to focus on the effect of interest rate risk.

Monetary policy. Monetary policy in our model is summarized by two parameters, r and σ, and a random variable $\tilde{v}$. r is the one-period (net) interest rate from T_0 to T_1. It is known at T_0 and represents the *tightness* of the monetary policy environment. $r+\sigma\tilde{v}$ is the future one-period interest rate from T_1 to T_2, which is unknown at T_0 because the *interest rate shock* , $\tilde{v}$, is a random variable to be realized at T_1. We assume that $\tilde{v}$ is drawn from a uniform distribution with zero mean, unit variance,

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[20] The RFY phenomenon has been documented for various institutional investors, including money market funds (La Spada, 2018; Di Maggio and Kacperczyk, 2017) and insurance companies (Ivashina and Becker, 2015). A theoretical argument for institutional investors' engagement in reaching-for-yield behaviour is the agency problem of fund managers. See Chodorow-Reich (2014), Feroli et al. (2014) and Morris and Shin (2014). Recently, Lian et al. (2019) show that in laboratory experiments, individual investors also exhibit reaching-for-yield behaviours.

[21] Table IA.6 illustrates the NAV adjustment patterns surrounding FOMC meetings for both high-yield and low-yield funds. The findings are in line with the results showcased in Table 5. Across both types of funds, a consistent observation emerges: there are delayed and incomplete adjustments observed prior to FOMC meetings in high-staleness funds, suggesting the presence of a temporary mispricing phenomenon preceding FOMC meetings.

[22] Interestingly, the coefficient magnitudes of Eurodollar rates in the window of (5, 15] (columns 7–9) are smaller than in Table 6, especially for low stale funds. Meanwhile, one of the RFY predictors (1Y Yield) is highly significant. These results suggest that in this window where the mispricing in NAVs should have largely disappeared, the persistent effect on outflows documented in Table 6 could be partially attributed to the RFY narrative, which is in line with the above discussion that tilting a bond portfolio takes time.

[23] There is weak predictability in NAV changes for both equity and Treasury funds. We also caution against the results regarding Treasury funds because there are only a few of them (around 80) in the sample.

that is, $\tilde{v} \sim U(-\sqrt{3}, \sqrt{3})$. The parameter $\sigma \in \left(0, \frac{1+r}{\sqrt{3}}\right)$ captures the monetary policy uncertainty over T_1 and T_2. At T_1, each investor i receive a signal x_i about the realization of $\tilde{v}$, denoted as v. Mapping the model into reality, T_1 corresponds to the date when financial markets learn about the future policy rate set by the central bank. T_1 can be days before the actual announcement at FOMC meetings.

Investors and a Bond Mutual Fund. There are a continuum of investors and an open-ended bond mutual fund (“the fund”). Each investor has one unit of cash invested in the fund and in return owns one share of the fund. The nature of “open-endedness” allows investors to redeem their shares at the fund’s latest net asset value (NAV) at T_1. Investors can also hold on their shares to T_2 and share the fund’s asset with all the remaining investors. We assume that the fund invests all the cash received from investors in the bonds at T_0, buying $\frac{1}{p_0}$ units of the bonds at the initial price p_0.

Stale NAV and Market Illiquidity. Right before T_1, i.e., before investors receive signals about v, the bond price is $\bar{p}_1 := \mathbb{E}\left[\frac{1}{1+r+\sigma\tilde{v}}\right]$. After v is realized, the bond value becomes $p_1(v) = \frac{1}{1+r+\sigma v}$. For clarity, we will call $p_1(v)$ the *realized* bond value and $\frac{1}{p_0}p_1(v)$ the *intrinsic* fund value. Crucially, the NAV of the fund share is partially stale and does not fully reflect the realized bond value. We assume $\text{NAV} := \frac{1}{p_0} \times [s\bar{p}_1 + (1-s)p_1]$, where $s \in (0,1)$ is the staleness of the NAV. Indeed, a completely stale NAV behaves as if the bond values have not changed at all ($\lim_{s\to 1} \text{NAV} = \bar{p}_1/p_0$) while NAV with no staleness fully reflects the realized bond values ($\lim_{s\to 0} \text{NAV} = p_1/p_0$). Upon receiving information about v, or, equivalently, the realized bond values p_1, investors choose to redeem their shares at the NAV or to stay. To repay the redeeming investors, the fund needs to liquidate some bonds at the price $\mathcal{L}p_1$, where the exogenous liquidation discount factor, $\mathcal{L} \in (0,1)$, reflects the liquidity of the bond market. It stems from the inventory cost of the market maker, search costs in the over-the-counter market, and bargaining power of the counterparties.

The Redemption Game and Investors’ Payoffs. Each investor observes a private signal about the shock v and then individually decides whether to redeem her share or not.[24] The information structure will be discussed formally in Section 3.2. Redeeming investors have a claim to receive the NAV at T_1 and the staying investors share the fund’s remaining cash flow at T_2. In addition, we assume that staying investors derive non-monetary utility ψ (normalized by the amount of initial bond holding $\frac{1}{p_0}$) if the fund is not liquidated. $\psi > 0$ captures the unmodelled benefits of owning a diversified bond portfolio in a bond fund. Alternatively, we can interpret ψ as the additional costs borne by investors when they redeem from the fund and construct the bond portfolio by themselves. Either way, within the context of the model, ψ justifies the existence of funds so that (risk-neutral) investors cannot costlessly replicate the funds by themselves.

Table 1 summarizes the payoff of fund investors at T_2. Suppose a fraction $\lambda \in [0,1]$ of investors redeem. To satisfy the redemption claims λNAV, the fund has to sell $\frac{\lambda\text{NAV}}{\mathcal{L}p_1}$ units of the bond. There is enough bond and hence the fund is not completely liquidated if and only if $\lambda \leq \frac{\mathcal{L}p_1}{s\bar{p}_1+(1-s)p_1}$. In this case, a redeeming investor receives the NAV and re-invests the proceeds in the bond, getting a return $\frac{1}{p_1}$. The fund continues to hold $\left(\frac{1}{p_0} - \frac{\lambda NAV}{\mathcal{L}p_1}\right)$ units of the bonds. The proceeds are shared among the $(1-\lambda)$ staying investors who also enjoy the non-pecuniary benefits of ψ/p_0. If $\lambda > \frac{\mathcal{L}p_1}{s\bar{p}_1+(1-s)p_1}$, the fund is completely liquidated. The total liquidation proceeds $\frac{1}{p_0}\mathcal{L}p_1$ are shared and re-invested by the λ redeeming investors while staying investors receive nothing at T_2.

3.2. Equilibrium

Given the investors’ payoffs, we are ready to characterize the investors’ optimal redemption strategies and solve for the equilibrium. We first show that there exist multiple equilibria if investors observe the interest rate shock perfectly. Then, by introducing idiosyncratic noise in investors’ private signals, we characterize the unique equilibrium in which investors follow a threshold strategy. This so-called global-game technique allows us to compute the ex-ante probability of full redemption on the fund (i.e., “fund run”), which we interpret as the *fragility* of the bond fund.

3.2.1. Multiple equilibria under perfect signals

Suppose that right before T_1, all investors receive perfect signals about the interest rate shock v, i.e., $x_i = v$ for all i. Then, there are three regions in which investors’ optimal redemption strategy differs.

The first region is a high-v region. When $v \geq \bar{v}$, redemption is the dominant strategy. That is, it is optimal for an investor to redeem even when all investors stay ($\lambda = 0$). The critical value $\bar{v}$ is implicitly defined by

$$\frac{\text{NAV}}{p_1} > \frac{1+\psi}{p_0} \Leftrightarrow v \geq \bar{v} := \frac{1}{\sigma}\left(\frac{\psi + s}{s\bar{p}_1} - (1+r)\right). \tag{4}$$

Intuitively, when the interest rate is high enough, or the realized bond value is low enough, redeeming the fund share at the stale NAV is very attractive. Thus, the only equilibrium is one in which all investors redeem.

Similarly, when $v < \underline{v}$, the realized bond value is so high that even if all other investors redeem ($\lambda = 1$), the fund has enough of the bond to liquidate and repay the redeeming investors. That is,

$$\lambda = 1 < \frac{\mathcal{L}p_1}{s\bar{p}_1 + (1-s)p_1} \Leftrightarrow v < \underline{v} := \frac{1}{\sigma}\left(\frac{s-(1-\mathcal{L})}{s\bar{p}_1} - (1+r)\right). \tag{5}$$

In this region, all investors staying is the only equilibrium.

To ensure the bounds $\underline{v}$ and $\bar{v}$ are within the support of interest rate shocks $\tilde{v}$, and hence the dominance regions exist, we make the following parametric assumptions.

Assumption 1 (*Parametric Assumptions*)**.** For a given$\{r, s\}$, $\sigma \in (\underline{\sigma}, (1+r)/\sqrt{3})$, $\mathcal{L} \in (\underline{\mathcal{L}}, 1)$, and $\psi \in (0, \bar{\psi})$.

We derive the bounds $\underline{\sigma}$, $\underline{\mathcal{L}}$, and $\bar{\psi}$ in Appendix. Importantly, in the non-empty intermediate region $v \in (\underline{v}, \bar{v})$, multiple equilibria exist. To see this, we define the payoff difference between redeeming and staying for an investor as

$$\Delta\pi(\lambda) = \begin{cases} \frac{\text{NAV}}{p_1} - \frac{1}{1-\lambda} \times \left(\frac{1}{p_0} - \frac{\lambda NAV}{\mathcal{L}p_1}\right) - \frac{\psi}{p_0} & \text{if } 0 \leq \lambda \leq \frac{\mathcal{L}p_1}{s\bar{p}_1+(1-s)p_1} \\ \frac{\mathcal{L}}{p_0\lambda} & \text{otherwise.} \end{cases} \tag{6}$$

We note that when $v \in [\underline{v}, \bar{v}]$, $\Delta\pi(0) < 0$ and $\Delta\pi(1) > 0$. That is, it is optimal for an investor to redeem (stay) if all other investors redeem (stay). The following lemma summarizes the discussion.

Lemma 1 (*Multiple Equilibria Under Perfect Signals*)**.** *If investors observe interest rate shock v perfectly, there exists a region $v \in [\underline{v}, \bar{v}]$ in which multiple equilibria exist.*

Proof. See the preceding discussion. □

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[24] In the model, we do not allow for potential inflows of capital from new investors. This could be incorporated by assuming inflow that is an increasing function of the underpricing of fund shares, i.e., a decreasing function of v. This would reduce the net outflow when v is negative. Our mechanism should be left unchanged qualitatively.

3.2.2. Global game and bond fund fragility

In order to compute the likelihood of a run on the fund and study the effect of monetary policy on this likelihood, we apply the global-game techniques and achieve a unique equilibrium in which investors follow an optimal threshold strategy. Specifically, we assume that investors receive noisy signals x_i about the realized interest rate v right before T_1, given by $x_i = v + \varepsilon_i$, where the signal noise $\{\varepsilon_i\}$ is independent across investors and follows a uniform distribution with support $[-\varepsilon, +\varepsilon]$.[25] We assume ε is positive but arbitrarily small. This allows us to invoke the standard result in the global-game literature (Morris and Shin, 2003; Goldstein and Pauzner, 2005) that there exists a unique symmetric equilibrium in which all investors follow the following threshold strategy:

$$\begin{cases} \text{Redeem} & x_i > v^* \\ \text{Stay} & x_i \le v^*. \end{cases}$$

The equilibrium threshold signal v^* is determined by the condition that the investor who has the threshold signal is indifferent between redeeming or staying. In addition, when $\varepsilon \to 0$, as explained in detail in Morris and Shin (2003), this marginal investor has a belief that the fraction of redeeming investors λ is uniformly distributed over $[0, 1]$. We can then compute the ex-ante probability of fund run, which is our notion of fragility, by using the prior distribution of the interest rate shocks $\tilde{v}$. We summarize these results in Proposition 1.

Proposition 1 (*Unique Threshold Equilibrium Under Incomplete Information*). *There exists a unique Perfect Bayesian Equilibrium. In this equilibrium, for realization of $v > v^*$, all investors redeem ($\lambda = 1$). For realization of $v \le v^*$, all investors stay ($\lambda = 0$). The threshold v^* is characterized by*

$$\frac{1}{1 + r + \sigma v^*} = \bar{p}_1 \frac{s g(\mathcal{L}, \psi)}{1 - (1 - s) g(\mathcal{L}, \psi)}, \tag{7}$$

where $g(\mathcal{L}, \psi)$ is the unique solution to

$$\mathcal{L} + log(1 - \mathcal{L}g)\left(1 - \frac{1}{\mathcal{L}g}\right) - log(\mathcal{L}g)\mathcal{L} = 1 + \psi\mathcal{L}g. \tag{8}$$

In addition, $g(1, 0) = 1$, $\frac{\partial g}{\partial \mathcal{L}} < 0$, and $\frac{\partial g}{\partial \psi} < 0$.

Proof. See the Appendix A.2 ☐

Proposition 1 delivers the first sharp empirical prediction on investors' equilibrium behaviour—large redemption occurs when the interest rate shock is positive and large enough. We call this monetary-policy-induced fragility in bond funds. In the same spirit as Chen et al. (2010), we interpret the ex-ante probability of the equilibrium in which all investors redeem, i.e., $\mathbb{P}(\tilde{v} > v^*)$ as the fragility of bond funds and measure it empirically using the sensitivity of fund outflows with respect to interest rate changes.

Definition 1. The fragility of the fund is defined as the probability that all investors redeem and thus the fund is fully liquidated, i.e., $\mathbb{P}(\tilde{v} > v^*)$.

Eq. (7) illustrates the economic forces behind the monetary-policy-induced fragility in bond funds. Using (7), the definitions of the realized bond value $p_1(v) = \frac{1}{1+r+\sigma v}$ and NAV, all investors redeem in equilibrium if and only if $v > v^*$, or,[26]

$$\text{NAV} g(\mathcal{L}, \psi) > \frac{1}{p_0} p_1(v). \tag{9}$$

This condition says that all investors redeem and hence the fund is completely liquidated when the NAV of the fund, multiplied by a factor $g(\mathcal{L}, \psi)$, is greater than the intrinsic value of the fund $\frac{1}{p_0} p_1(v)$. The intuition of the condition can be seen clearly in the special case in which the bond market is perfectly liquid ($\mathcal{L} \to 1$) and the non-pecuniary benefits of staying in the fund are negligible ($\psi \to 0$). In this case, $g(\mathcal{L}, \psi)$ becomes 1 and investors behave like arbitrageurs, redeeming the shares whenever the NAV is above the bond fund's intrinsic value.

In general, $g(\mathcal{L}, \psi) \neq 1$ because investors are concerned about the illiquidity of bonds and they value the benefits of staying in the fund ψ. Fix $\psi > 0$ and consider the effect of liquidity. On one hand, when the liquidity of the bond worsens ($\mathcal{L}$ decreases) enough, $g(\mathcal{L}, \psi) > 1$ and, from Eq. (7), $\bar{p}_1 < p_1(v^*)$. That is, investors redeem their shares even if the NAV is below the intrinsic value of the bond fund's share (recall $\text{NAV} = \frac{1}{p_0}[s\bar{p}_1 + s p_1(v^*)] < \frac{1}{p_0} p_1(v^*)$). This is because of the redemption externalities discussed in Section 3.1. When the fund has to liquidate the bond at a discount to repay the redeeming investors, investors who stay have to incur the losses. On the other hand, when liquidity is high enough, $g(\mathcal{L}, \psi) < 1$ and $\bar{p}_1 > p_1(v^*)$. In this case, investors are less concerned about redemption externalities and choose to stay even when the NAV is strictly above the intrinsic value of the bond fund's share.

Using the results in Proposition 1, we can conduct comparative static analyses to study how market illiquidity, staleness, and monetary policy environment affect fragility. This set of results forms the theoretical underpinning of the main hypotheses in Section 3.3.

Corollary 1 (*Fund Fragility in Illiquid Times, Stale Funds, and Loose Monetary Policy Environment*). *For a given ψ and σ,*

(a). $\frac{\partial \mathbb{P}(\tilde{v} > v^*)}{\partial(-\mathcal{L})} > 0$;
(b). $\frac{\partial \mathbb{P}(\tilde{v} > v^*)}{\partial s} > 0$ *for* $\mathcal{L} \in [\tilde{\mathcal{L}}, 1]$ *and* $\frac{\partial \mathbb{P}(\tilde{v} > v^*)}{\partial s} < 0$ *otherwise;*
(c). $\frac{\partial \mathbb{P}(\tilde{v} > v^*)}{\partial(-r)} > 0$ *for* $\mathcal{L} \in [\tilde{\mathcal{L}}, 1]$ *and* $\frac{\partial \mathbb{P}(\tilde{v} > v^*)}{\partial(-r)} < 0$ *otherwise;*

Proof. See the Appendix A.3. ☐

To understand the results above, it is useful to recall the condition for redemption (9). Corollary 1(a) states that illiquidity makes funds more fragile. As $g(\mathcal{L}, \psi)$ decreases in $\mathcal{L}$, (9) holds for a larger range of v. Intuitively, for a given amount of redemption, more assets have to be liquidated in illiquid times. Investors who stay will incur higher costs and are thus more inclined to redeem.

Corollary 1(b) shows that whether staleness in the NAV makes funds more or less fragile depends on market liquidity. When liquidity is high, investors behave like arbitrageurs and redeem to profit from the temporary overpricing in the NAV. Staleness increases the scope of overpricing hence making funds more fragile. The more surprising result arises when liquidity is low. In this case, investors are so concerned about redemption externalities that they would redeem even if the intrinsic fund value is going to increase ($\bar{p}_1 < p_1(v^*)$). Then, at the threshold $p_1(v^*)$, an increase in staleness *reduces* NAV because $\frac{\partial}{\partial s}\text{NAV} = \frac{1}{p_0}(\bar{p}_1 - p_1(v^*)) < 0$. At this decreased NAV, the shares are more *underpriced*. Investors are thus less inclined to redeem and funds become less fragile.

Corollary 1(c) shows that funds are more (less) fragile in a loose monetary policy environment when liquidity is high (low). When liquidity is high, investors redeem only if there is sufficient overpricing in NAV. As the bond is more sensitive to interest rate changes in a lower interest rate regime, a given positive interest rate shock reduces bond value more, resulting in more overpricing in the NAV. In contrast, when liquidity is low, investors are inclined to redeem and will only stay if the bond value increases enough. It is easier to achieve such a bond value increase in a lower interest rate regime and hence fragility is reduced.

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[25] We follow Goldstein and Pauzner (2005) to use the information structure of uniform prior of v and uniform signal noise ε_i. This is for simplicity and can be relaxed to a more general distribution of prior and a noise distribution that satisfies the monotone likelihood ratio property as shown in Morris and Shin (2003).

[26] To derive (9), $v > v^* \Leftrightarrow p_1(v) < \frac{1}{1+r+\sigma v^*} = \bar{p}_1 \frac{s g(\mathcal{L},\psi)}{1-(1-s)g(\mathcal{L},\psi)} \Leftrightarrow p_1(v) < g(\mathcal{L}, \psi) \underbrace{[s\bar{p}_1 + (1 - s)p_1(v)]}_{\text{NAV} p_0}$

3.3. Main hypotheses

Hypothesis 1. There is a positive relationship between fund outflows and changes in the Federal Funds Target rate.

The first hypothesis is our notion of monetary-policy-induced fragility in corporate bond funds. It arises due to the temporary mispricing in the NAV. An increase in the Federal Funds Target rate tends to decrease bond and thus corporate bond fund values, stale NAV implies that the fund shares are temporarily overpriced. Hence, investors have stronger incentives to redeem their shares.

Hypothesis 2. Funds with less liquid assets exhibit stronger sensitivity of outflows to change in Federal Funds Target rate. The same prediction holds for more illiquid periods.

The second hypothesis stems from the concern of redemption externalities. An increase in the Federal Funds Target rate causes temporary overpricing in NAVs, inducing some investors to redeem their shares. Their redemption, in turn, leads to costly liquidation of the corporate bonds and such costs are borne by investors who stay. Thus, when liquidity reduces, more investors redeem.

Hypothesis 3. Funds with higher staleness exhibit stronger sensitivity of outflow to change in the Federal Funds Target rate when liquidity is high. As liquidity decreases, the effect of staleness on the sensitivity reduces and eventually becomes negative.

Hypothesis 3 states the interactive effects of illiquidity and staleness and is the first novel hypothesis from our model. In the case of high liquidity, fund investors are not concerned with the redemption externalities. They behave like arbitrageurs and redeem when the shares are overpriced. Following an increase in the Federal Funds Target rate, the intrinsic fund values decrease. NAVs with higher staleness, by definition, reflect a smaller fraction of the reduction in fund values. Hence, ceteris paribus, there is more *overpricing* in NAVs, inducing more fund investors to redeem. In contrast, when liquidity is low enough, fund investors so concerned with the redemption externalities that they would redeem even if the fund values are expected to rise. In this case, NAVs with higher staleness rise less and the fund shares are more *underpriced*, weakening investors' incentive to redeem.

Hypothesis 4. In a loose monetary policy environment, funds exhibit stronger sensitivity of outflow to a change in the Federal Funds Target rate when liquidity is high. As liquidity decreases, the effect of looseness in monetary policy reduces and eventually becomes negative.

Hypothesis 4 describes the effect of the monetary policy environment and is the second novel hypothesis from our model. In a low-interest-rate environment, bonds have higher duration and consequently, for a given change in the target Fed funds rate, stale NAVs result in more mispricing. As discussed in the previous hypothesis, investors redeem due to the overpricing in the NAVs when liquidity is high whereas they would only stay if there is enough underpricing in the NAVs when liquidity is low. Therefore, a loose monetary policy environment exacerbates (reduces) outflows when liquidity is high (low).

4. Tests of model predictions

This section is devoted to empirically testing the hypotheses outlined in Section 3.3. Specifically, we will regress outflows on changes in policy rates, interacting with illiquidity, staleness, and monetary policy environment. We present evidence from both the daily and monthly samples to provide a comprehensive analysis. While the daily sample offers tighter identification, the monthly sample extends further back in time, encompassing different market conditions.

To ensure comparability between the daily and monthly results, we use the predicted FFTar change within the [−1,1] window around the FOMC meeting as the explanatory variable. This predicted FFTar change, denoted as $\widehat{\Delta\text{FFTar}_{[-1,1]}}$, is in percentage points and is estimated with $\Delta\text{Eurodollar}(\tau+5,-5]$. For the daily analysis, we adopt the same set of controls as in Eq. (3) except for one change: past flows are excluded because their effects on flows presumably act through illiquidity, of which the impact is directly estimated here.

For the monthly analysis, we conduct a panel regression using the following specification:

$$OutFlow_{i,m} = \Delta\text{FFTar}_m + \text{Controls} + \alpha_i + \varepsilon_{i,m} \tag{10}$$

where $OutFlow_{i,m}$ represents the outflows from fund share i in month m, while the key explanatory variable ΔFFTar_m is the change in FFTar over the same month. In addition to the macro variables included in specification (1), we incorporate fund-level controls to account for other factors that may influence fund flows. These fund-level controls include the fund's previous month's return, performance, TNA in log scale, expense ratio, percentage of cash and government bond holdings, and an indicator for high-yield funds.[27] Our analysis focuses on the months that coincide with FOMC meetings to reduce noise. Additionally, we assign weights to each observation based on the fund's TNA value from the previous month. Furthermore, we address the potential intertemporal dependence of flows across funds and over time by clustering the standard errors at both the fund share and month levels.

4.1. The monetary policy-induced fragility

We begin with testing Hypothesis 1 to establish the outflow–ΔFFTar relationship using monthly data. We find results consistent with the analyses of daily data presented in Section 2.3.2, as shown in Table IA.11. In addition, we uncover an asymmetry in the relationship: the outflow response to an increase in FFTar is more pronounced than the inflow response to a decrease in FFTar. This asymmetry justifies our focus on outflows, hence, fragility induced by monetary policy.

The more pronounced relationship between outflows and increases in FFTar stems from the strategic complementarities among investors' redemption, which are absent for capital inflows. To see this asymmetry, consider a fund with underpriced shares relative to their intrinsic values. When investors deposit capital to purchase the underpriced shares, the fund suffers a loss and the intrinsic share value drops, reducing the underpricing. In contrast, if the fund shares are overpriced, investors' redemption further erodes the fund's intrinsic value, exacerbating the overpricing. Thus, strategic complementarities arise specifically for capital outflows but not for inflows.[28]

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[27] Following Goldstein et al. (2017), the performance of fund i at month t is measured as the past one year's alpha from the following time-series regression:

$$R^e_{i,\tau} = \text{Perf}_{i,t-12\to t-1} + \eta_B R^e_{B,\tau} + \eta_M R^e_{M,\tau} + \varepsilon_{i,\tau}, \quad \tau \in (t-12, t-1) \tag{11}$$

where $R^e_{i,\tau}$, $R^e_{B,\tau}$ and $R^e_{M,\tau}$ denote excess returns of the fund share i, the aggregate bond market and the aggregate stock market, respectively. The risk-free rate is approximated by the Federal Funds rate. $R_{B,\tau}$ is approximated by the Vanguard total bond market index fund return from Bloomberg and $R_{M,\tau}$ is approximated by CRSP value-weighted market return. We chose this measurement because it allows us to calculate performance over our entire sample period. In Appendix Table IA.12, we demonstrate the robustness of our main results by measuring performance using the intercept from a regression of excess fund returns on portfolio-sorted corporate bond factors proposed by Bai et al. (2019) and the instrumented principal component factor proposed by Kelly et al. (2023).

[28] It is worth noting that decreases in FFTar frequently occur in reaction to unforeseen events, whereas rate increases are typically subject to more prolonged deliberation. This distinction could also contribute to asymmetrical responses in flows to future rates.

Table 7

Asymmetric flow response and monetary policy-induced fragility (monthly evidence). This table examines the impact of monetary policy changes on fund flows of corporate bond mutual funds from January 1992 to June 2023. Only months with FOMC meetings are included in the analysis. The table studies the outflow-rate relationship in the entire sample (columns 1-2), in months with non-negative FFTar moves (columns 3-4), and in months with non-positive FFTar moves (columns 5-6). $\text{OutFlow}_{i,m}$ represents the outflows of fund share i in month m, and ΔFFTar_m denotes the percentage point changes in FFTar. To account for the COVID-19 pandemic, we include an indicator variable that is equal to one for the FOMC meeting on March 3, 2020, and zero otherwise. The macro controls, $\Delta\text{Controls}^M_m$, include the change in the Baa-Aaa Spread, the change in the spread between the 30-year and 1-year treasury yields, and the logarithmic change in the VIX index. Fund characteristics encompass the previous month's performance, return, TNA on a logarithmic scale, expense ratio, percentage of cash and government bond holdings, and a high-yield fund indicator. Each observation is weighted by the TNA value of the fund from the previous month. Coefficients (standard errors) are reported in shaded (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	$\text{OutFlow}_{i,m}(\%)$ in Months with FOMC meetings					
	All		$\Delta\text{FFTar}_m \geq 0$		$\Delta\text{FFTar}_m \leq 0$	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔFFTar_m	1.299***	0.742***	2.114***	1.511***	0.552*	0.212
	(0.258)	(0.246)	(0.305)	(0.421)	(0.311)	(0.377)
$\Delta\text{Controls}^M_m$	✓	✓	✓	✓	✓	✓
$\text{Controls}^F_{i,t-1}$		✓		✓		✓
Fund FE		✓		✓		✓
Observations	511,253	336,848	458,772	310,880	410,964	279,079
Adjusted R^2	0.022	0.090	0.014	0.081	0.019	0.092

The results in Table 7 illustrate the asymmetric relationship. In months with non-negative FFTar changes, we observe 0.378% outflows for a 25-basis-point increase in FFTar (column 4), which is over seven times greater than the inflows observed in months with non-positive FFTar changes (column 6). We emphasize that our analysis has already controlled for fund performance (alpha). This ensures our monetary policy-driven fragility is not driven by the flow-performance relationship documented in Goldstein et al. (2017).

4.2. The amplifying effect of illiquidity

Hypothesis 2 states that redemption externalities are intensified when liquidity is lower, leading to a stronger relationship between outflows and ΔFFTar. To test this hypothesis, we measure liquidity in two ways: fund-level liquid asset holdings and market liquidity. Moreover, in order to isolate the effect of illiquidity, we control for staleness by adding an indicator variable for high-stale funds. Under either measure of liquidity, the results strongly support this hypothesis.

For a fund-level liquidity measure, we use each fund's cash and government bond holdings in the year before each FOMC meeting. This measure aligns with existing work on the use of cash and liquid assets by open-end funds to reduce fragility and fire sales risks (Liu and Mello, 2011; Zeng, 2017; Chernenko and Sunderam, 2020; Choi et al., 2020; Ma et al., 2022b). Funds with liquid asset holdings above (below) the sample median are classified as liquid (illiquid) funds.

The results regarding fund-level liquidity are reported in Table 8. Panel A presents the findings using daily data. Consistent with the redemption externality hypothesis, we observe that the coefficient loadings of $\widehat{\Delta\text{FFTar}}_{[-1,1]}$ are significantly higher for the sub-sample of illiquid funds compared to liquid funds. For instance, illiquid funds exhibit a cumulative outflow of 0.218% in the five days preceding FOMC meetings, given a 25-basis-point increase in FFTar (column 1). This value is larger than that of liquid funds (column 2). Furthermore, the estimates of interaction effects in columns 6 and 9 confirm the significant difference in the sensitivity of outflows to $\widehat{\Delta\text{FFTar}}_{[-1,1]}$ between illiquid and liquid funds.

With monthly data, we extend our analysis to illiquid market conditions. Specifically, we proxy bond market illiquidity with the VIX index and categorize months into liquid and illiquid periods based on whether the VIX index falls below or above the bottom or top tercile, respectively, throughout the sample period.[29]

The findings are presented in the first three columns of Panel B in Table 8. We observe a significant outflow–ΔFFTar sensitivity only in months characterized by high values of the VIX index (column 1). On average, a 25-basis-point increase in FFTar is associated with a 0.65% increase in outflows during these months. We note that this effect size is approximately twice as large as the average effect size of 0.378% observed in column 4 of Table 7. In the last three columns, we conduct the analyses with the fund-level liquidity measure and reach a similar conclusion.

4.3. The stabilizing effect of staleness under distress

The results in the previous section demonstrate that illiquid funds or periods experience greater fragility in response to monetary policy changes. In this section, we document a seemingly counter-intuitive finding that the staleness in NAVs could have a stabilizing effect in such circumstances.

The effect of staleness is discussed in Hypothesis 3, which states that staleness mitigates (exacerbates) monetary-policy-induced fragility when liquidity is low (high). These predictions are confirmed in Table 9, where we present results using daily and monthly data.[30] We test the stabilizing effect of staleness by estimating regressions with three-way interaction effects in both panels. The results demonstrate that the sensitivity between outflows and $\widehat{\Delta\text{FFTar}}_{[-1,1]}$ increases for illiquid funds, but this effect is attenuated for high-staleness funds, as indicated by the negative coefficients of $\widehat{\Delta\text{FFTar}}_{[-1,1]}\times\mathbb{1}(\text{Illiquid funds})\times\mathbb{1}(\text{high-staleness})$.

Overall, the results highlight a novel channel in which staleness in NAVs could promote stability in corporate bond mutual funds for illiquid funds or during periods of market stress. This finding has two implications. First, it helps explain why fund managers might not always want to update NAVs promptly, even if they have some discretion

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[29] Dick-Nielsen et al. (2012) construct a corporate bond market illiquidity index. However, this index is only available starting from July 2002, which would limit our sample period. Therefore, we opted to use the VIX index from the Chicago Board Options Exchange (CBOE) as a proxy for corporate bond market illiquidity. It is worth noting that the VIX index exhibits a high Pearson correlation of 87.5% with the DFL index, indicating a strong relationship between the VIX index and corporate bond market illiquidity. Additionally, research by Bao et al. (2011) also supports the positive correlation between the VIX index and the illiquidity of corporate bonds.

[30] It merits emphasis that at the bond level, staleness and illiquidity are expected to exhibit a significant correlation. However, in our analysis, illiquidity is assessed based on the proportion of liquid asset holdings at the fund level. Consequently, the illiquidity measure does not show a high correlation with the staleness measure. In Panel B of Table IA.1, we demonstrate that the sub-samples created based on the staleness and illiquidity measures at the fund level are relatively balanced. This suggests that the sub-samples capture different aspects of fund characteristics.

Table 8
The amplifying effect of illiquidity on monetary policy-induced fragility. The table investigates the impact of fund illiquidity on monetary policy-induced fragility around FOMC meetings, with separate analyses conducted for daily and monthly data presented in Panel A and Panel B, respectively. In Panel A, for each FOMC meeting, we classify funds whose last year's percentage holding of liquid assets (cash and government bonds) is higher-(lower-)than-sample median as liquid (illiquid) funds. The dependent variables are the cumulative fund outflows, measured in percentage points, for each fund share i within three different time windows around FOMC meetings: $(-5,-1]$, $(-1,5]$, and $(5,15]$, with 0 representing the date of the FOMC meeting. The predicted changes in FFTar, also in percentage points, are based on $\Delta\text{Eurodollar}(\tau+5,-5]$, denoted as $\widehat{\Delta\text{FFTar}}_{[-1,1]}$. We include one-year lagged fund characteristics, such as the total net asset in log scale, expense ratios, high-staleness fund indicator, high-yield fund indicator as controls, denoted as $\text{Controls}^{F}_{i,t-1}$. To account for the COVID-19 pandemic, we include an indicator variable that is equal to one for the FOMC meeting on March 3, 2020, and zero otherwise. In Panel B, the analysis focuses on months with FOMC meetings and non-negative Federal Fund Target rate moves. High (Low) VIX months refer to months with a VIX index above (below) the top (bottom) tercile of the sample. Low (High) CashBond funds denote funds with a proportion of cash and government bond holdings below (above) the bottom (top) tercile within each Lipper objective category of each year. Fund characteristics encompass the previous month's performance, return, TNA on a logarithmic scale, expense ratio, a high-staleness fund indicator, and a high-yield fund indicator. $\Delta\text{Controls}^{M}_{m}$ is the same as in Table 7. Each observation is weighted by the TNA value of the fund from the previous month. Coefficients (standard errors) are reported in shaded (unshaded) rows. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

Panel A: Daily evidence

	$\text{OutFlows}_{i,(-5,-1]}$			$\text{OutFlows}_{i,(-1,5]}$			$\text{OutFlows}_{i,(5,15]}$		
	Illiquid (1)	Liquid (2)	All (3)	Illiquid (4)	Liquid (5)	All (6)	Illiquid (7)	Liquid (8)	All (9)
$\widehat{\Delta\text{FFTar}}_{[-1,1]}$	0.873***	0.533***	0.533***	1.699***	1.073***	1.073***	1.905***	1.142***	1.142***
	(0.206)	(0.109)	(0.110)	(0.311)	(0.279)	(0.279)	(0.396)	(0.314)	(0.314)
$\widehat{\Delta\text{FFTar}}_{[-1,1]} \times \mathbb{1}(\text{Illiquid funds})$			0.340			0.626**			0.763***
			(0.218)			(0.290)			(0.240)
$\text{Controls}^{F}_{i,t-1}$	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	90,506	88,549	179,055	90,515	88,587	179,102	90,056	88,097	178,153
Adjusted R^2	0.115	0.086	0.099	0.136	0.095	0.112	0.146	0.107	0.124

Panel B: Monthly evidence

	$\text{OutFlow}_{i,m}(\%)$ in Months with FOMC meetings & $\Delta\text{FFTar}_m \geq 0$					
	Liquid vs. illiquid market condition			Liquid vs. illiquid funds		
	High VIX (1)	Low VIX (2)	All (3)	Low CashBond (4)	High CashBond (5)	All (6)
ΔFFTar_m	2.604***	−0.698	−0.698	2.458***	0.149	0.149
	(0.737)	(0.746)	(0.743)	(0.582)	(1.085)	(1.085)
$\Delta\text{FFTar}_m \times \mathbb{1}(\text{High VIX})$			3.302***			
			(1.087)			
$\Delta\text{FFTar}_m \times \mathbb{1}(\text{Low CashBond})$						2.309**
						(1.093)
$\Delta\text{Controls}^{M}_{m}$	✓	✓	✓	✓	✓	✓
$\text{Controls}^{F}_{i,t-1}$	✓	✓	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓	✓	✓
Observations	78,864	86,897	165,761	77,515	73,981	151,496
Adjusted R^2	0.128	0.156	0.141	0.145	0.092	0.114

in the determination of NAVs. The prior literature views the prevalence of stale NAVs as an agency problem in which fund managers engage in return smoothing. In this sense, we point out the bright side of return smoothing. Second, our results highlight the potential destabilizing effects of staleness-reducing policies during market distress.

4.4. *The impact of monetary policy environments*

Hypothesis 4 states that funds exhibit a stronger sensitivity of outflows to changes in FFTar in a loose (tight) monetary policy environment when liquidity is high (low).

To test these predictions, we conduct an analysis using a longer sample with monthly data. We divide the sample into different monetary policy regimes based on the FFTar values. Specifically, we classified months into loose or tight policy regimes based on whether the FFTar was below or above the bottom or top tercile, respectively, over the sample period.

We find results consistent with both predictions. Table 10 presents the results for both liquid periods (Panel A) and liquid funds (Panel B). We find that during illiquid periods or for illiquid funds, capital flows out more aggressively from funds in response to increases in FFTar when the monetary policy environment is tight (column 1 of both panels). In contrast, we observe the opposite results for liquid periods or for liquid funds, shown in column 2 of both panels. The negative coefficients on the three-way interaction term $\Delta\text{FFTar}_m \times \mathbb{1}(\text{Low FFTar}_m) \times \mathbb{1}(\text{Illiquid})$ further confirms the result that the redemption externalities in distressed periods or funds with less liquidity cause more outflows in the tight monetary policy regime (than in a loose regime).

This set of results suggests *when* policymakers should pay special attention to this new unintended consequence of monetary policy. We find that increases in FFTar trigger strong outflow responses from illiquid funds during illiquid times, and that this effect is intensified under a tight monetary policy regime.

5. Conclusion

Since the 2008 global financial crisis, the Federal Reserve has actively maintained a low Federal Funds Target rate to ease the financing conditions of the real sector. However, academics and regulators have voiced concerns regarding various potential negative consequences of this expansionary monetary policy. In this paper, we propose a novel channel via which monetary policy can contribute to the fragility of the increasingly important corporate bond mutual fund sector. Policymakers might thus want to be mindful of this negative consequence of monetary policy.

We conclude by highlighting the novel policy implications of our analyses. First, staleness in NAVs could dampen outflow during stressed periods. Second, changes in policy rates have particularly strong effects on outflow during illiquid periods in a tight policy regime. These results suggest that policies or regulations that aim to enhance the stability of corporate bond funds should be contingent on the funds' staleness, market liquidity, and monetary policy environment.

Table 9

The stabilizing effect of staleness on monetary policy-induced fragility in distress. The table examines the impact of fund staleness on monetary policy-induced fragility in illiquid funds or during illiquid periods, using daily and monthly data presented in Panel A and B, respectively. In Panel A, the focus is on funds with a last year's percentage holding of liquid assets (cash and government bonds) below the sample median, which are categorized as illiquid funds. Funds experiencing a higher (lower) proportion of non-moving NAV days in the non-FOMC window leading up to the preceding FOMC meeting, compared to the median, are classified as high-staleness (low-staleness) funds (which we refer to as high-stale and low stale funds to conserve space). The dependent variables are the cumulative fund outflows, measured in percentage points, for each fund share i within three different time windows around FOMC meetings: (−5,−1], (−1,5], and (5,15], with 0 representing the date of the FOMC meeting. The predicted changes in FFTar, also in percentage points, are based on ΔEurodollar$(\tau+5,-5]$, denoted as $\widehat{\Delta\text{FFTar}}_{[-1,1]}$. We include one-year lagged fund characteristics, such as the total net asset in log scale, expense ratios, and high-yield fund indicator as controls, denoted as $\text{Controls}^{F}_{i,t-1}$. To account for the COVID-19 pandemic, we include an indicator variable that is equal to one for the FOMC meeting on March 3, 2020, and zero otherwise. In Panel B, the analysis is conducted on months with FOMC meetings and non-negative Federal Fund Target rate moves. The sub-sample of illiquid months includes months with a VIX index above the top tercile of the sample. Similarly, the sub-sample of illiquid funds comprises funds with a proportion of cash and government bond holdings below the bottom tercile within each Lipper objective category of each year. High-staleness (low-staleness) funds are identified as those with a proportion of non-moving NAV days in the previous month higher (lower) than the top (bottom) tercile. Fund characteristics encompass the previous month's performance, return, TNA on a logarithmic scale, expense ratio, and a high-yield fund indicator. $\Delta\text{Controls}^{M}_{m}$ is the same as in Table 7. Each observation is weighted by the TNA value of the fund from the previous month. Notably, two-way interactions are not reported in the table. Coefficients (standard errors) are reported in shaded (unshaded) rows. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

Panel A: Daily evidence

	$\text{OutFlows}_{i,(-5,-1]}$	$\text{OutFlows}_{i,(-1,5]}$	$\text{OutFlows}_{i,(5,15]}$
	(1)	(2)	(3)
$\widehat{\Delta\text{FFTar}}_{[-1,1]}$	0.390***	0.845***	0.853***
	(0.097)	(0.260)	(0.315)
$\widehat{\Delta\text{FFTar}}_{[-1,1]} \times \mathbb{1}$(Illiquid funds)	0.367	0.735***	1.189***
	(0.253)	(0.270)	(0.339)
$\widehat{\Delta\text{FFTar}}_{[-1,1]} \times \mathbb{1}$(Illiquid funds) $\times\mathbb{1}$(High-stale)	−0.328	−0.648*	−0.665
	(0.265)	(0.379)	(0.511)
$\text{Controls}^{F}_{i,t-1}$	✓	✓	✓
Fund FE	✓	✓	✓
Observations	179,055	179,102	178,153
Adjusted R^2	0.091	0.102	0.111

Panel B: Monthly evidence

	$\text{OutFlow}_{i,m}(\%)$ in Months with FOMC meetings & $\Delta\text{FFTar}_m \geq 0$	
	(1)	(2)
ΔFFTar_m	−1.290	−1.367
	(0.923)	(1.375)
$\Delta\text{FFTar}_m \times \mathbb{1}$(High VIX)	4.122***	
	(1.434)	
$\Delta\text{FFTar}_m \times \mathbb{1}$(Low CashBond)		2.851**
		(1.307)
$\Delta\text{FFTar}_m \times \mathbb{1}$(High VIX) $\times\mathbb{1}$(High-stale)	−2.915*	
	(1.545)	
$\Delta\text{FFTar}_m \times \mathbb{1}$(Low CashBond) $\times\mathbb{1}$(High-stale)		−3.352**
		(1.624)
$\Delta\text{Controls}^{M}_{m}$	✓	✓
$\text{Controls}^{F}_{i,t-1}$	✓	✓
Fund FE	✓	✓
Observations	165,761	151,493
Adjusted R^2	0.141	0.119

CRediT authorship contribution statement

John Chi-Fong Kuong: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **James O'Donovan:** Writing – review & editing, Validation, Supervision, Conceptualization. **Jinyuan Zhang:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Replication Pack for "Monetary Policy and Fragility in Corporate Bond Mutual Funds" (Reference data) (Mendeley Data)

Appendix. Proofs

A.1. Parameter restrictions in Assumption 1

For a given $\{r, s, \sigma\}$, $\bar{p}_1$ is fixed. Using the definition of $\bar{v}$ and $\underline{v}$, the conditions for $\bar{v}$ and $\underline{v}$ to be within the support $\left[-\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}\right]$ can be written as

$$\mathcal{L} > 1 - s + s\bar{p}_1[(1+r) - \sigma/\sqrt{3}] \equiv \underline{\mathcal{L}} \tag{A.1}$$

$$\psi < s\bar{p}_1[(1+r) + \sigma/\sqrt{3}] - s \equiv \bar{\psi} \tag{A.2}$$

Intuitively, if the liquidation cost is too high ($\mathcal{L} < \underline{\mathcal{L}}$), staying can never be a dominant strategy. Similarly, if the benefit of staying in the fund is too high ($\psi > \bar{\psi}$), redeeming can never be a dominant strategy. $\bar{\psi} > 0$ as $\bar{p}_1(1+r) - 1 > 0$ due to Jensen's inequality ($p_1 = \frac{1}{1+r+\sigma v}$ is a

Table 10

The effect of monetary policy environment on monetary policy-induced fragility (monthly evidence). The table examines the impact of the monetary policy environment on monetary policy-induced fragility for corporate bond mutual funds from January 1992 to June 2023. A loose monetary policy environment refers to months with FFTar below the bottom tercile of the sample (Low FFTar), while a tight monetary policy environment refers to months with FFTar above the top tercile of the sample. Panel A compares the effects in liquid versus illiquid market conditions. Illiquid market conditions refer to months with a VIX index above the top tercile of the sample (High VIX months), while the opposite applies to Low VIX months. Panel B compares the effects in liquid versus illiquid funds. We refer to illiquid funds as those holding a proportion of cash and government bond holdings below the bottom tercile within each Lipper objective category of each year (Low CashBond Funds), while the opposite applies to Low CashBond funds. Fund characteristics encompass the previous month's performance, return, TNA on a logarithmic scale, expense ratio, percentage of cash and government bond holdings and a high-yield fund indicator. $\Delta\text{Controls}^M_m$ is the same as in Table 7. Each observation is weighted by the TNA value of the fund from the previous month. To account for the COVID-19 pandemic, we include an indicator variable that is equal to one for the FOMC meeting on March 3, 2020, and zero otherwise. Coefficients (standard errors) are reported in shaded (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

Panel A: Liquid vs. illiquid market condition

	$\text{OutFlow}_{i,m}(\%)$ in Months with FOMC meetings		
	High VIX months (1)	Low VIX months (2)	All sample (3)
ΔFFTar_m	1.708***	−0.275	−0.216
	(0.417)	(0.405)	(0.429)
$\Delta\text{FFTar}_m \times \mathbb{1}(\text{Low FFTar})$	−2.232**	2.508**	−0.065
	(0.960)	(1.221)	(0.987)
$\Delta\text{FFTar}_m \times \mathbb{1}(\text{High VIX})$			1.524***
			(0.469)
$\Delta\text{FFTar}_m \times \mathbb{1}(\text{Low FFTar}) \times \mathbb{1}(\text{High VIX})$			−2.934**
			(1.206)
$\Delta\text{Controls}^M_m$	✓	✓	✓
$\text{Controls}^F_{i,t-1}$	✓	✓	✓
Fund FE	✓	✓	✓
Observations	70,325	72,116	142,441
Adjusted R^2	0.220	0.190	0.163

Panel B: Liquid vs. illiquid funds

	$\text{OutFlow}_{i,m}(\%)$ in Months with FOMC meetings		
	Low CashBond funds (1)	High CashBond funds (2)	All sample (3)
ΔFFTar_m	1.102*	0.187	0.243
	(0.593)	(0.296)	(0.303)
$\Delta\text{FFTar}_m \times \mathbb{1}(\text{Low FFTar})$	−1.736**	0.970	1.427
	(0.749)	(0.838)	(0.881)
$\Delta\text{FFTar}_m \times \mathbb{1}(\text{Low CashBond})$			0.873
			(0.652)
$\Delta\text{FFTar}_m \times \mathbb{1}(\text{Low FFTar}) \times \mathbb{1}(\text{Low CashBond})$			−2.807**
			(1.229)
$\Delta\text{Controls}^M_m$	✓	✓	✓
$\text{Controls}^F_{i,t-1}$	✓	✓	✓
Fund FE	✓	✓	✓
Observations	76,936	74,262	151,198
Adjusted R^2	0.189	0.163	0.159

convex function in ν). Moreover, as $\sigma \to (1+r)/\sqrt{3}$, $\underline{\mathcal{L}} \to 1 - s < 1$. There exists a $\underline{\sigma} \in (0, (1+r)/\sqrt{3})$ such that for $\sigma > \underline{\sigma}$, $\underline{\mathcal{L}} < 1$.

A.2. Proposition 1

Proof. In this proof, we first establish the existence of a unique equilibrium with a symmetric switching strategy. Then, we characterize the equilibrium threshold ν^*. Finally, we establish the listed properties of the important equilibrium function $g(\mathcal{L}, \psi)$.

Existence of a unique equilibrium. The existence of a unique equilibrium with a symmetric switching strategy, in which every investor redeems when $\nu > \nu^*$ and stays when $\nu < \nu^*$, follows from Morris and Shin (2003), Lemma 2.3. Below we show that $\Delta\pi(\lambda, \nu)$ satisfies the assumptions A1* (Action Single Crossing) and A2 (State Monotonicity) in Morris and Shin (2003). It is immediate to check that the remaining assumptions A3, A4, A5, and A7 are also satisfied.

First, we show that $\Delta\pi(\lambda, \nu)$ satisfies Action Single Crossing A1*. That is, for any $\nu \in (\underline{\nu}, \bar{\nu})$, there exists a unique $\hat{\lambda}$ such that $\Delta\pi(\lambda, \nu) < 0$ when $\lambda < \hat{\lambda}$ and $\Delta\pi(\lambda, \nu) > 0$ when $\lambda > \hat{\lambda}$. We note that at $\lambda = 0$, $\Delta\pi(0, \nu) < 0$. For $\lambda \leq \dfrac{\mathcal{L}p_1}{s\bar{p}_1 + (1-s)p_1}$, $\Delta\pi(\lambda, \nu)$ strictly increases in λ. For $\lambda > \dfrac{\mathcal{L}p_1}{s\bar{p}_1 + (1-s)p_1}$, $\Delta\pi(\lambda, \nu)$ strictly decreases in λ. Finally, at $\lambda = 1$, $\Delta\pi(1, \nu) > 0$. Therefore, there is exactly one such $\hat{\lambda}$ exists.

For A2 State Monotonicity, we need to show $\Delta\pi(\lambda, \nu)$ is non-decreasing in ν, or, non-increasing in p_1. For a given λ, for low enough p_1, the fund is liquidated and $\Delta\pi(\lambda, \nu)$ does not depend on p_1. As p_1 increases to the point where the fund is not fully liquidated, $\frac{\partial \Delta\pi(\lambda,\nu)}{\partial p_1} = \dfrac{-s\bar{p}_1}{(1-\lambda)p_1} < 0$. Hence $\Delta\pi(\lambda, \nu)$ is decreasing in p_1. Putting the two cases together, $\Delta\pi(\lambda, \nu)$ is non-increasing in p_1.

Equilibrium threshold ν^*. Next, we invoke the standard result in global game that shows as the signal noise goes to zero $\varepsilon \to 0$, the proportion of investors redeeming λ given switching threshold ν^* is uniformly distributed over [0,1] (Morris and Shin, 2003; Goldstein and Pauzner, 2005). In the equilibrium, the marginal investor receiving signal ν^* is indifference between investing in the fund and the bank, that is, $\int_\lambda \Delta\pi(\lambda, \nu^*) d\lambda = 0$. With above results, this equation can be written as

$$\underbrace{\int_0^{\frac{\mathcal{L}p_1/p_0}{\text{NAV}}} \left(\frac{\text{NAV}}{p_1} - \frac{1}{1-\lambda} \times \left(\frac{1}{p_0} - \frac{\lambda \text{NAV}}{\mathcal{L}p_1} \right) - \frac{\psi}{p_0} \right) d\lambda}_{\text{net payoff when the fund is liquid}}$$

$$+ \qquad \underbrace{\int_{\frac{\mathcal{L}p_1/p_0}{\text{NAV}}}^{1} \frac{\mathcal{L}}{p_0\lambda} d\lambda}_{\text{net payoff when the fund is illiquid}} \qquad = 0.$$

Rearranging the above equation and denoting $X = \frac{p_1}{p_0\text{NAV}}$ gives

$$\mathcal{L} + log(1 - \mathcal{L}X)\left(1 - \frac{1}{\mathcal{L}X}\right) - log(\mathcal{L}X)\mathcal{L} = 1 + \psi\mathcal{L}X. \tag{A.3}$$

We note that the solution for X in the above equation is a function of $\mathcal{L}$ and ψ only. We denote $X = g(\mathcal{L}, \psi)$. Rearrange above equation gives the expression (7).

Properties of $g(\mathcal{L}, \psi)$**.** For the following proof, it is useful to recall the following inequalities (Topsok, 2006):

$$\frac{2z}{2+z} \geq log(1+z) \geq \frac{z}{2} \cdot \frac{2+z}{1+z} \quad \text{for} \ -1 < z \leq 0$$

We first show that there exist a unique solution $X = g(\mathcal{L}, \psi) \in (0, \frac{1}{\mathcal{L}})$ to Eq. (7). The $log(1-\mathcal{L}X)$ and $log(\mathcal{L}X)$ in Eq. (7) requires the solution $g(\mathcal{L}, \psi) \in (0, \frac{1}{\mathcal{L}})$. We define $h(X)$ function as below

$$h(X) := \mathcal{L} + log(1 - \mathcal{L}X)\left(1 - \frac{1}{\mathcal{L}X}\right) - log(\mathcal{L}X)\mathcal{L} - 1 - \psi\mathcal{L}X = 0$$

Equation (7) is rewritten as $h(X) = 0$. For any given $\mathcal{L} \in (0, 1)$ and $\psi > 0$, we note that $h(X)$ is continuous, $\lim_{X\to 0} h(X) > 0$, and $\lim_{X\to\frac{1}{\mathcal{L}}} h(X) < 0$. Also $h'(X) < 0$ since it has the same sign as

$$\begin{aligned}
& -\mathcal{L}^2X + \mathcal{L}X - (\mathcal{L}X)^2\psi + log(1 - \mathcal{L}X) \\
\leq \quad & -\mathcal{L}^2X + \mathcal{L}X + log(1 - \mathcal{L}X) \\
\leq \quad & -\mathcal{L}^2X + \mathcal{L}X - \frac{2\mathcal{L}X}{2 - \mathcal{L}X} < 0
\end{aligned}$$

Hence, there exists a unique solution $X = g(\mathcal{L}, \psi) \in (0, \frac{1}{\mathcal{L}})$ such that $h(X) = 0$.

Next, we show that $\frac{\partial g}{\partial\mathcal{L}} < 0$. By implicit function theorem, $\frac{\partial g}{\partial\mathcal{L}} = -\frac{\frac{\partial h}{\partial\mathcal{L}}}{\frac{\partial h}{\partial X}}$. As $\frac{\partial h}{\partial X} < 0$, $\frac{\partial g}{\partial\mathcal{L}}$ has the same sign as $\frac{\partial h}{\partial\mathcal{L}}$, which is

$$\begin{aligned}
& \log(1 - \mathcal{L}X) - \mathcal{L}X(\mathcal{L}\psi X + \mathcal{L}\log(\mathcal{L}X) - 1) \\
= \quad & \log(1 - \mathcal{L}X) - \mathcal{L}X(-2 + \mathcal{L} + \log(1 - \mathcal{L}X)(1 - \frac{1}{\mathcal{L}X})) \qquad \text{as} \quad h(X) = 0 \\
= \quad & \log(1 - \mathcal{L}X)(2 - \mathcal{L}X) + 2\mathcal{L}X(1 - X) \\
\leq \quad & \frac{-2\mathcal{L}X}{2 - \mathcal{L}X}(2 - \mathcal{L}X) + 2\mathcal{L}X(1 - X) < 0
\end{aligned}$$

By a similar argument, $\frac{\partial g}{\partial\psi} < 0$ because $\frac{\partial h}{\partial\psi} = -\mathcal{L} < 0$.

Lastly, we show $\lim_{\mathcal{L}\to 1} g(\mathcal{L}, 0) = 1$. For $\psi = 0$, we can write the condition $h(X) = 0$ as

$$\log(1 - \mathcal{L}X)\left(1 - \frac{1}{\mathcal{L}X}\right) - \log(\mathcal{L}X)\mathcal{L} = 1 - \mathcal{L} \tag{A.4}$$

We note that the left hand side (L.H.S. of) (A.4) is strictly positive for any $X < \frac{1}{\mathcal{L}}$ and is decreasing in X. As $\mathcal{L} \to 1$, the R.H.S. of (A.4) approaches to 0. The L.H.S. approaches 0 only when $\mathcal{L}X \to 1$. This completes the proof that $\lim_{\mathcal{L}\to 1} g(\mathcal{L}, 0) = 1$. □

A.3. Corollary 1

Proof. **Proof for part (a)**: Using Eq. (7),

$$\begin{aligned}
sign(\frac{\partial v^*}{\partial\mathcal{L}}) &= sign\left(\frac{\partial}{\partial\mathcal{L}}[1 - (1 - s)g(\mathcal{L}, \psi)]/sg(\mathcal{L}, \psi)\right) \\
&= sign(-\frac{\partial g}{\partial\mathcal{L}}) > 0. \quad \square
\end{aligned}$$

Proof for part (b): Using Eq. (7),

$$sign(\frac{\partial v^*}{\partial s}) = sign\left(\frac{\partial}{\partial s}[1 - (1 - s)g(\mathcal{L}, \psi)]/sg(\mathcal{L}, \psi)\right) = sign(g(\mathcal{L}, \psi) - 1)$$

For any given $\psi \geq 0$, as $\mathcal{L} \to 1$, $g(\mathcal{L}, \psi) < 1$ and $\frac{\partial v^*}{\partial s} < 0$. That is, staleness increases fragility when market is liquid enough. As $\frac{\partial g}{\partial\mathcal{L}} < 0$, $\frac{\partial}{\partial\mathcal{L}}(\frac{\partial v^*}{\partial s}) < 0$.

It remains to characterize $\tilde{\mathcal{L}}(\psi)$ such that for $\mathcal{L} < \tilde{\mathcal{L}}(\psi)$, $g(\mathcal{L}, \psi) > 1$ and hence $\frac{\partial v^*}{\partial s} > 0$. Define $\tilde{h}(\mathcal{L}, \psi) := h(1) = \mathcal{L} + \log(1 - \mathcal{L})\left(1 - \frac{1}{\mathcal{L}}\right) - \log(\mathcal{L})\mathcal{L} - 1 - \psi\mathcal{L}$. For any given $\psi > 0$, define $\tilde{\mathcal{L}}(\psi)$ which satisfies $\tilde{h}(\tilde{\mathcal{L}}(\psi), \psi) = 0$, or equivalently, $g(\tilde{\mathcal{L}}(\psi), \psi) = 1$. We note that since $\lim_{\mathcal{L}->0} \tilde{h}(\mathcal{L}, \psi) = 0$ and $\lim_{\mathcal{L}->0} \frac{\partial\tilde{h}}{\partial\mathcal{L}} = +\infty$, $\tilde{h}(\epsilon, \psi) > 0$ for an arbitrarily small ϵ. Combine with the facts that $\lim_{\mathcal{L}->1} \tilde{h}(\mathcal{L}, \psi) = -\psi < 0$ and $\frac{\partial^2\tilde{h}}{\partial\mathcal{L}^2} < 0$, there exists a unique $\tilde{\mathcal{L}}(\psi) \in (0, 1)$ that satisfies $\tilde{h}(\mathcal{L}(\psi), \psi) = 0$, or equivalently, $g(\tilde{\mathcal{L}}(\psi), \psi) = 1$. Finally, as $\frac{\partial g}{\partial\mathcal{L}} < 0$, $g(\mathcal{L}, \psi) > 1$ for $\mathcal{L} < \tilde{\mathcal{L}}(\psi)$. □

Proof for part (c):

The partial derivative of v^* on r is

$$\frac{\partial v^*}{\partial r} = \frac{1}{\sigma}\left(\frac{1 - (1 - s)g(\mathcal{L}, \psi)}{sg(\mathcal{L}, \psi)}\frac{1}{\bar{p}_1^2}\mathbb{E}\left[p_1^2\right] - 1\right).$$

For a given $\psi > 0$, as $\mathcal{L} \to 1$, $g(\mathcal{L}, \psi) < 1$. Then, $\frac{\partial v^*}{\partial r} > 0$ because

$$\begin{aligned}
& \frac{1 - (1 - s)g(\mathcal{L}, \psi)}{sg(\mathcal{L}, \psi)}\frac{1}{\bar{p}_1^2}\mathbb{E}\left[p_1^2\right] - 1 \\
\geq & \frac{1}{\bar{p}_1^2}\mathbb{E}\left[p_1^2\right] - 1 \\
= & \frac{\text{Var}(p_1)}{\bar{p}_1^2} > 0
\end{aligned}$$

Furthermore, $\frac{\partial}{\partial(-\mathcal{L})}(\frac{\partial v^*}{\partial r}) < 0$. This is because as $\mathcal{L}$ decreases, $g(\mathcal{L}, \psi)$ increases and $\frac{\partial v^*}{\partial r}$ decreases and can become negative. □

Appendix B. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jfineco.2024.103931.

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