Monetary Policy and Fragility in Corporate Bond Funds *

John Kuong† & Jinyuan Zhang‡

This version: October, 2020

Abstract

This paper examines flow patterns in corporate bond mutual funds under different monetary policy environments. We build a model of runs in funds with uncertain future interest rates, uncovering a novel outflow-to-interest-rate relationship. Consistent with the model's predictions, we empirically find that (1) outflows from funds increase when the target Fed funds rate increases, (2) the outflow-to-interest-rate sensitivity is stronger under more accommodative and uncertain monetary policy environments, and (3) these monetary-policy-induced flow sensitivities are greater when the bond market is more liquid. Our results suggest that fragility in corporate bond funds could be an important unintended consequence of monetary policy.

Keywords: monetary policy, corporate bond mutual funds, fund redemption, financial fragility, market liquidity

*This paper benefits tremendously from discussions with Bernard Dumas, Marcin Kacperczyk, and Naveen Gondhi and Joel Peress. In addition, comments and feedback are greatly appreciated from participants at HEC Doctoral Workshop and SMU seminar.

†INSEAD; john.kuong@insead.edu; 1 Ayer Rajah Ave, 138676, Singapore .

‡INSEAD; jinyuan.zhang@insead.edu; Boulevard de Constance, Fontainebleau 77300, France.

1 Introduction

Corporate bond mutual funds, as an asset class, have experienced dramatic growth since the financial crisis in 2008.[1] Its ever-growing size has raised much attention from regulators and researchers about its potential as a threat to the stability of the financial system.[2] The primary concern comes from the fact that (open-end) mutual funds allow their investors to redeem their shares at a daily frequency while they invest in generally illiquid corporate bonds. Fund managers, in the face of significant redemption from investors, may thus be forced to sell a sizable amount of assets in an illiquid market, further prompting investors to redeem their shares before others, triggering "runs on funds." Goldstein, Jiang, and Ng (2017) document such behaviors and find that investors' flows are sensitive to performances achieved by funds. In this paper, we highlight a new potential threat embedded in the corporate bond mutual funds: their flows are also sensitive to interest rates set by policymakers.

The crucial element behind the flow-to-interest-rate relationship is the temporary mispricing of fund shares around interest rate changes. Fund investors can redeem their shares at the daily-closed net asset value (NAV) on any given day. Given that very few corporate bonds are traded more than once per day[3], the latest transaction prices of bonds, which are used to calculate the NAV, might not reflect recent news. One obvious source of news that can affect bond prices across the board is monetary policy changes. Intuitively, an increase in the target fed fund (TFF) rate would reduce corporate bonds' fundamental values and, thus, the fund's NAV. Until some transactions of each bond owned by the fund take place, the fund's NAV will not fully reflect the decrease in their fundamental values. Investors can, therefore, make a profit by redeeming the shares at the stale

[1] From 2008 to 2017, the total asset under management in corporate bond mutual funds has gone up by three times, reaching $2 trillion, while the outstanding corporate bond has only increased from $5.4 trillion to $8.5 trillion over the same period, according to Securities Industry and Financial Markets Association (SIFMA).

[2] See, for example, the Financial Stability Board's 2017 report.

[3] For instance, Friewald, Wagner, and Zechner (2014) show that from October 2004 to December 2008, the mean trading interval of corporate bonds is 4.46 days. The 5^{th} percentile is 1.5 days.

NAV. If the bonds' prices decrease (so does the fund's NAV) after the redemption, then the fund has to sell more shares to fulfill the redemption requirement, eroding assets left for the non-withdrawal investors. As a result, this prompts the latter to redeem as soon as possible when they receive some signals that suggest others' redemption. Therefore, monetary policy shock can generate "runs on funds," and can result in volatile asset prices and negative spillovers to other parts of the financial system.

In the first half of the paper, we build a model of runs on a bond fund to capture the above feature and analyze how monetary policy affects fund runs. We show that when investors receive private signals about future interest rate changes, they will redeem from the fund when the signal suggests a high enough interest rate. Observing a (signal of) high-interest rate shock makes redemption at the NAV attractive for two reasons. First, it implies that the bond price, and thus, the value of the fund share will decrease. Second, the NAV, which is based on the *expected* bond price, contains a premium over the *realized* bond price at the expected interest rate due to the uncertainty in the future interest rate and the convexity of the bond price. Hence, investors withdraw from the fund once they receive a signal of high enough interest rate; that is, there exhibit a positive outflow-to-interest-rate relationship. Furthermore, as discussed before, these withdrawals impose negative externalities on non-withdrawal investors, prompting runs on the fund. Such strategic behaviors enhance the positive outflow-to-interest-rate relationship. Importantly, our proposed runs on the fund prevail in a perfectly liquid bond market.

We then establish that a more accommodative and uncertain monetary policy environment increases the incidence of coordinated redemption in bond funds caused by interest rate changes. This is because, by Jensen's inequality, the premium in the NAV is larger when the bond price is more convex, which is when the current interest rate is lower, and when the volatility of interest rate shocks is higher. A larger premium, in turn, incentivizes investors to collectively redeem.

The last set of analytical results show that market illiquidity mitigates the monetary-policy-induced fund fragility discussed above. Intuitively, illiquidity itself encourages redemptions, as the losses imposed on the remaining investors become more substantial. The bond price thus has to increase substantially more to deter investors' redemption. In this case, a loose monetary policy may help because bond price increases more for the same interest rate drop. The same for monetary policy uncertainty since a large enough interest rate drop is more likely.

In the second half of the paper, we provide empirical evidence for all the predictions discussed above. We start with panel regressions using monthly corporate bond mutual fund data from January 1992 to December 2017 and then identify the effect through applying the event study methodology on the Federal Open Market Committee (FOMC) meetings. First, we document a significantly positive relation between outflows from the corporate bond funds and the change in target Fed funds (TFF) rate. The relationship is robust after controlling for potential macro-and micro-drivers for fund flows. Macro controls include the term-structure of bonds, the default risk, and bond market illiquidity; micro controls include fund performance, constructed following Goldstein, Jiang, and Ng (2017), past returns, total net asset, and expense ratio. The results show that, on average, a 25 basis point increase in the TFF rate is accompanied by 0.29% outflows, roughly 5.3 billion USD benchmarked to the total size of corporate bond mutual funds in 2017. This result confirms a strong outflow-to-interest-rate relationship as predicted by the model.

Next, we find that the outflow-to-interest-rate relationship is much stronger in more accommodative and uncertain monetary environments. Specifically, during periods with low TFF rates, a 25 basis point increase in the TFF rate is associated with 1.13% outflows, more than five times higher than the expansionary regime. Similarly, when monetary policy uncertainty is high, a 25 basis point increase in the TFF rate is associated with 0.70% outflows, which is higher than 0.45% in low uncertainty regimes. Moreover, looseness and uncertainty of monetary policy reinforce each other on bond mutual fund fragility. These results highlight the effect of Jensen's inequality on investors' decisions to run from the funds.

Then, we provide evidence that market illiquidity, proxied by high VIX index, high TED spread, or high DLF index constructed by Dick-Nielsen, Feldhütter, and Lando (2012), weakens fragility induced by monetary policy looseness and uncertainty. In months with high VIX index and low TFF rates, the TFF rate change is not associated with outflow at all, while the average effect in a low-interest-rate regime is 1.13%. Similarly, in months with high VIX index and high monetary policy uncertainty, a 25 basis point increase in the TFF rate is only associated with 0.24% outflows, significantly smaller than the average effect of 0.70% reported in a high-monetary-policy-uncertainty regime. To strength the analysis, we further provide cross-sectional evidence using illiquidity proxies at the fund share level. A bond fund needs to liquidate more illiquid bonds to fulfill the redemption requirement when there is a shortage of liquid assets, such as cash or liquid government bonds. Hence, we use the level of cash holdings, or both cash and government bonds holdings as the proxy for illiquidity. The cross-sectional analysis reveals similar results that the bond illiquidity mitigates the monetary-policy-induced fund fragility.

Following the argument that interest rate shocks drive investors' flows, we suspect that the flow-to-interest-rate effect should be more substantial for bond funds whose assets are more sensitive to interest rate risk. We examine this hypothesis by comparing low- versus high-yield bond funds. Low-yield bonds are similar to zero-coupon bonds and hence are more sensitive to interest rate shocks. In contrast, the valuation of high-yield bonds highly depends on their default risk. The evidence is consistent with our intuition that looseness-enhanced and uncertainty-enhanced fragility concentrate on low-yield funds. Next, we move to understand how fund investors' characteristics play a role in our context. We compare institutional- and retail-oriented funds and find that institutional-oriented funds exhibit a weaker flow-to-interest-rate relationship but a more significant sensitivity change when the interest rate or uncertainty regime shifts. These results hint that profiting from stale NAV may not be very attractive for institutional investors, unless the mispricing is relatively large, for example, in lower-interest-rate or higher-uncertainty periods.

To further attribute the outflow patterns to monetary policy changes, we examine outflows over a narrow window *right before* each FOMC meeting using the event study method. The results show significant outflows within a five-day window before FOMC meetings with an increase in the effective Fed funds (FF) rates. In terms of magnitude, a 25 basis point increase in the FF rate is associated with 0.24% outflows, very close to 0.29% calculated previously using monthly flows. The evidence suggests that the majority of monthly outflows due to interest rate changes concentrate in a short window before FOMC meetings. Furthermore, when we calculate outflows five-more-day ahead, over [-10, -6] before FOMC meetings, there is no evidence of flows in either direction. We further the identifying analysis for monetary-policy-looseness-enhanced fragility. We show that fund investors redeem more shares within a five-day window before FOMC meetings with an increase in the FF rates in a loose monetary policy environment than in a tight one. Moreover, such an effect is weakened for illiquid bond funds (with a small amount of cash or cash and government bond holdings. Therefore, we can conclude that investors indeed respond to potential monetary policy changes in a way consistent with our predictions.

Lastly, we conduct several additional robustness tests of our findings. First, we run the subsample analysis on high/low-yield funds and institutional/retail-funds. The results show that monetary-policy-induced fragility presents in all cases but relatively weak for institutional-funds. The looseness- and uncertainty-enhanced fragility are prominent on low-yield funds and institutional funds. Second, to address the concern of the non-moving TFF rate in the zero-interest-rate era from 2009 to 2014, we re-do the analyses in subsample before 2009. The results are similar to our main finds.

Literature review This paper closely relates to works on the financial fragility of open-end mutual funds, which stems from the investors' payoff complementarities in redemptions. On the theory side, Chen, Goldstein, and Jiang (2010) examine how asset illiquidity increases the payoff complementarities and thus fragility in equity mutual funds. Liu and Mello (2011) and Zeng (2017) study the optimal liquidity management of funds to reduce fragility. Morris, Shim, and Shin (2017) and Goldstein (2017) ask when fund managers should hoard cash in anticipation of redemptions in the future. Empirical works have devoted to documenting the existence of fragility in different mutual funds. Adrian, Estrella, and Shin (2019) identify the impacts of investors' redemptions on fire sale discount in corporate bond markets, suggesting the existence of negative externalities in bond markets. Similarly, Feroli et al. (2014) find that fund outflows are positively correlated with declines in NAV, creating incentives for bond investors to leave funds simultaneously. Chen, Goldstein, and Jiang (2010) and Goldstein, Jiang, and Ng (2017) use outflow-to-poor-performance relationship as a proxy for strategic complementarities among equity and bond fund investors. Using structural recursive vector autoregression (VAR), Banegas, Montes-Rojas, and Siga (2016) also document that bond fund flows instrumented by the unexpected monetary policy are closely related to fund performance, indicating a first-mover advantage among investors. At a more micro level, Schmidt, Timmermann, and Wermers (2016) use daily money market mutual fund flow data to examine fund runs in money market mutual funds. All the above models and empirical evidence focus on fragility induced by illiquidity. Our paper highlights a novel notion of fragility induced by monetary policy.

The only papers modeling monetary policy and asset management sector together are Morris and Shin (2015) and Feroli et al. (2014). The model predicts a jump in risk premium when the central bank signals a higher interest rate. They assume that asset managers bear a cost of ranking last in the relative performance. When the central bank adjusts the return of the safe asset up, the cost of coming last alters managers' preference towards the safe option. Hence, managers sell the risk asset, pushing up its risk premium. The model is novel and can be generalized to different mutual funds. However, Banegas, Montes-Rojas, and Siga (2016) document the opposite effects of monetary policy on flows to equity mutual funds versus bond mutual funds. In contrast, our model is specific to bond mutual funds. We point out that the convexity in bond price is the key to bridge monetary policy and fund fragility.

Second, this paper contributes to the recent growing literature on the effect of monetary policy on the behavior of non-banking financial intermediaries. Adriana and Liangb (2018) provide an excellent survey. They highlight the endogenous risk-taking channel under an expansionary monetary policy for non-banking financial intermediaries. For example, Adrian and Shin (2008) show that an accommodative monetary policy increases intermediaries' incentives to take leverage. Di Maggio and Kacperczyk (2017), Choi and Kronlund (2017) and Ivashina and Becker (2015) document risk-taking behavior of money market funds, corporate bond mutual funds, and insurance companies over zero interest rate periods, respectively. This paper emphasizes that even without risk-taking or reaching-for-yield behavior by financial institutions, looser and more uncertain monetary policy environments could contribute to financial fragility in corporate bond funds because it strengthens the fund investors' incentives to redeem. This is a new source of unintended consequences of monetary policy.

The remainder of the paper is organized as follows. Section 2 presents the model and testable hypotheses. Section 3 presents the empirical analysis and tests the model's predictions. Section 5 concludes.

2 A Model of Fund Run

In this section, we develop a model of runs for an open-ended bond mutual fund with monetary policy (interest rate) risk.[4] Our analysis focuses on how interest rate risk induces fragility in the bond mutual fund and how different monetary policy environments affect the fund's fragility. We first describe the model set-up, then identify the equilibrium conditions, and last conduct a comparative statics analysis.

2.1 The Setup

There are three dates: T_0, T_1 and T_2. There is "cash" without time-discounting. There is only one type of asset traded in the market, namely, the zero-coupon long-term bonds ("the bonds") with

[4] In this paper, we narrow monetary policy to interest rate management.

face values 1 and maturity at T_2. To focus on the effect of interest rate risk, we assume the bond has no credit risk.

Monetary policy. Monetary policy in our model is summarized by three parameters, r, σ, and $\tilde{v}$. 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 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 with zero mean, unit variance, that is, $\tilde{v} \sim U(-\frac{\sqrt{12}}{2}, \frac{\sqrt{12}}{2})$. The parameter $\sigma > 0$ captures the *monetary policy uncertainty* over T_1 and T_2. The realization of $\tilde{v}$, denoted as v, is decided by the central bank right before T_1. T_1 corresponds to the date of the FOMC meeting, at which the central bank publicly announces the new interest rate $r + \sigma v$.

Investors and a bond mutual fund. There is a continuum of risk-neutral investors. Each investor has one unit of cash invested in an open-ended bond mutual fund ("the fund") and can redeem her capital from the fund right before T_1 or hold to T_2 to share the fund's assets.[5]

The fund acts as an investment vehicle of the bonds. 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. The nature of "open-endedness" allows investors to redeem their shares at the fund's latest net asset value (NAV), which is the market value of the fund's total assets.

NAV and redemption externality. Right before T_1, i.e., before the interest rate shock $\tilde{v}$ is announced, the bond price is $\bar{p}_1 \equiv \mathbb{E}\left[\frac{1}{1+r+\sigma\tilde{v}}\right]$ and the NAV of the fund share is $\frac{1}{p_0}\bar{p}_1$. Investors have the right to redeem their shares at this NAV. Then, at T_1, the central bank announces the new interest rate and the bond price adjusts to $p_1 = \frac{1}{1+r+\sigma v}$, where v is realized shock. To repay the

[5] We abstract away from the investors' decision to invest in the fund in the first place. Relative to direct investment in the bond, investing via the fund could have advantages of lower transaction costs and better diversification benefits.

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.[6]

The options granted to investors, who submit redemption notices right before T_1, allows them to withdraw at the NAV based on the market price of bond $\bar{p}_1$. When the price at the times of the bond sales p_1 at T_1 is below $\bar{p}_1$, the fund has to sell additional shares to pay the redemption proceeds. As a result, the fund assets remaining to share among the staying investors shrink, leading to strategic complementarities in investors' redemption decisions. This is the redemption externality generated by interest rate risk. The redemption externality is further magnified when the bond market becomes more illiquid (lower $\mathcal{L}$). We describe the redemption game and investors' payoffs in detail below.

The redemption game and investors' payoffs. Right before T_1, the interest rate shock is not announced by the central bank. Each investor observes a private signal about the shock v and then individually decides whether to redeem her share or not. The information structure will be discussed formally in Section 2.2. Redeeming investors have a claim to receive the NAV $\frac{\bar{p}_1}{p_0}$ at T_1 and the non-redeeming investors share the fund's remaining cash flow at T_2.

The investors' payoff at T_2 depends on how many other investors redeem, the realized interest rate shock hence the price of the bond p_1, and the liquidation discount $\mathcal{L}$. Suppose a fraction $\lambda \in [0, 1]$ of investors redeem. To satisfy the redemption claims $\lambda\frac{\bar{p}_1}{p_0}$, the fund has to sell $\lambda\frac{\bar{p}_1}{p_0}\frac{1}{\mathcal{L}p_1}$ units of bond. There is enough bond and hence the fund is not completely liquidated if and only if

$$\frac{1}{p_0} \geq \lambda\frac{\bar{p}_1}{p_0} \times \frac{1}{\mathcal{L}p_1} \quad \Longleftrightarrow \quad \lambda \leq \frac{\mathcal{L}p_1}{\bar{p}_1}. \tag{1}$$

Table 1 summarizes the payoff of fund investors at T_2. When $\lambda \leq \frac{\mathcal{L}p_1}{\bar{p}_1}$, a redeeming investor receives the NAV $\frac{\bar{p}_1}{p_0}$ and re-invests the proceeds in a bond , getting a return $\frac{1}{p_1}$. The fund continues

[6] The liquidation discount $\mathcal{L}$ stems from inventory cost of market maker, search costs in the over-the-counter market, and bargaining power of the counterparties.

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

Table 1: The payoff of investors at T_2.

to hold $\frac{1}{p_0} - \lambda\frac{\bar{p}_1}{p_0}\frac{1}{\mathcal{L}p_1}$ units of the bonds, and the proceeds are shared by $(1-\lambda)$ staying investors. If $\lambda > \frac{\mathcal{L}p_1}{\bar{p}_1}$, the fund is completely liquidated. The total liquidation proceeds $\frac{1}{p_0}\mathcal{L}p_1$ are shared and re-invested by λ redeeming investors, while a staying investor receives nothing at T_2.

The payoff of staying investors is plotted in Figure 1. It is immediate to see the redemption externality imposed by redeeming investors on the staying ones, and how it is magnified by bond illiquidity. Staying investors' payoffs first decrease in λ and then become zero when λ is high enough. Moreover, when the bond is less liquid (lower $\mathcal{L}$), the payoffs decrease at a higher rate and reach zero earlier. Importantly, the redemption externality exists even in a perfect liquid market where $\mathcal{L} = 1$, making our redemption externality fundamentally different from the one caused by bond illiquidity, see for example, Chen, Goldstein, and Jiang (2010); Goldstein, Jiang, and Ng (2017).

2.2 Equilibrium

Given the investors' payoffs, we are ready to characterize the investors' optimal redemption strategies and solve for equilibrium. We first show that there exist multiple equilibria if investors observe the interest rate shock perfectly. Then, by introducing idiosyncratic noises 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

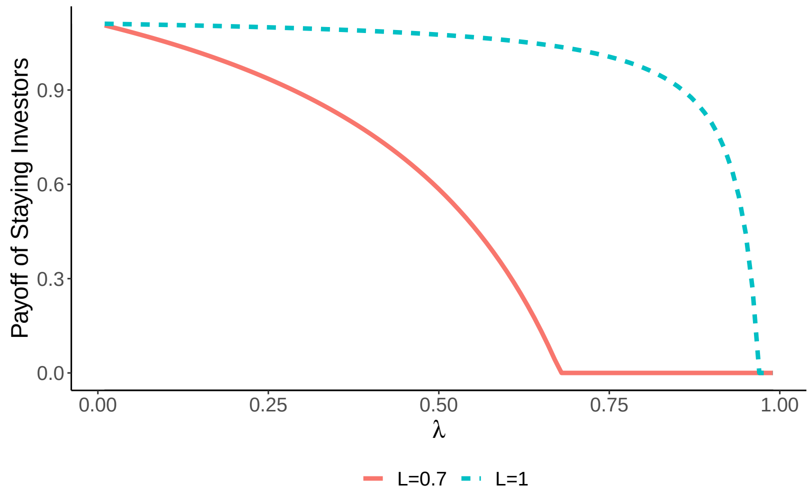

Figure 1: The payoff of staying investors at T_2.

on the bond mutual fund ("fund run"), which we interpret as the *fragility* of the bond fund.

2.2.1 Multiple equilibria under perfect signals

Suppose right before T_1, all investors receive perfect signals about the interest rate shock v, i.e., $s_i = v$ for all i. In this case, 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

$$\frac{\bar{p}_1}{p_0} \times \frac{1}{p_1} > \frac{1}{p_0} \Leftrightarrow v \geq \bar{v} \equiv \frac{1}{\sigma}\left(\frac{1}{\bar{p}_1} - (1+r)\right). \tag{2}$$

Intuitively, when the interest rate is high enough, or the bond price is low enough, redeeming the fund share at the NAV is very attractive. Thus, all investors redeeming is the only equilibrium.

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

$$\lambda = 1 < \frac{\mathcal{L}p_1}{\bar{p}_1} \Leftrightarrow v < \underline{v} \equiv \frac{1}{\sigma}\left(\frac{\mathcal{L}}{\bar{p}_1} - (1+r)\right). \tag{3}$$

In this region, staying is the dominant strategy, and hence, all investors staying is the only equilibrium.[7]

Finally, there is a non-empty region with intermediate value of $v \in (\underline{v}, \bar{v})$ if $\mathcal{L} < 1$. In this region, multiple equilibria exist. All investors redeem in one equilibrium, and all of them stay in the other. To see this, it is useful to define the payoff difference between redeeming and staying for an investor as

$$\Delta\pi(\lambda) = \begin{cases} \frac{\bar{p}_1}{p_0}\frac{1}{p_1} - \frac{1}{p_0(1-\lambda)} \times \left(1 - \frac{\lambda\bar{p}_1}{\mathcal{L}p_1}\right) & \text{if } 0 \le \lambda \le \frac{\mathcal{L}p_1}{\bar{p}_1} \\ \frac{\mathcal{L}}{p_0\lambda} & \text{otherwise.} \end{cases} \tag{4}$$

Notice that $\Delta\pi(0) < 0$ and $\Delta\pi(1) > 0$, implying that it is optimal to redeem (stay) if all other investors redeem (stay). In summary, there exist multiple equilibria when $v \in [\underline{v}, \bar{v}]$.

Lemma 1 (Multiple equilibria under common knowledge). *When $\mathcal{L} < 1$, there exists a region $v \in [\underline{v}, \bar{v}]$ in which multiple equilibria exist.*

Proof. See the Appendix A.1 □

2.2.2 Global game and fragility of bond fund

In order to compute the likelihood of the run on the fund and study the effect of monetary policy on it, 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 s_i about the realized interest rate v right before T_1, given by $s_i = v + \sigma_\varepsilon \varepsilon_i$, where $\sigma_\varepsilon > 0$ is a parameter that

[7] The payoff of staying $\lim_{\lambda\to1} = \frac{1}{p_0(1-\lambda)}\left(1 - \frac{\bar{p}_1}{\mathcal{L}p_1}\right) \to \infty$, is higher than the payoff of redemption, $\frac{\bar{p}_1}{p_0}\frac{1}{p_1}$.

captures the size of noise, and ε_i is an idiosyncratic component which has a cumulative distribution $F_\varepsilon(\cdot)$. The noise terms $\{\varepsilon_i\}$ are independent across investors, and its density function $f_\varepsilon(\cdot)$ is assumed log-concave to guarantee the monotone likelihood ratio property (MLRP).

Following Goldstein and Pauzner (2005), one can show that there exists a unique symmetric equilibrium—there is a cutoff threshold v^* such that every investor redeems from the fund if her signal is above the threshold and stays otherwise. This threshold strategy is as follows:

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

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 other words, the expected net payoff $\Delta\pi(\lambda)$ given signal v^* is 0:

$$\int_\lambda \Delta\pi(\lambda) f_{\lambda|v^*} d\lambda = 0. \tag{5}$$

As common in the literature, our analysis focuses on the case where the noises in signals become arbitrarily close to zero. As $\sigma_\varepsilon \to 0$, investors observe the interest rate shock v with almost perfect precision and the threshold signal approaches some state v^*. In other words, in equilibrium, all investors redeem if and only if the realized shock v is above the threshold v^*. Moreover, as explained in details in Morris and Shin (2003), v^* can be characterized easily by using (5), because for the investor who has the threshold signal v^*, λ is uniformly distributed over $[0, 1]$. Finally, one can easily 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). *For $\sigma_\varepsilon \to 0$, there is a unique perfect Bayesian equilibrium for investors. In this equilibrium, for realization of $v > v^*$, all investors redeem ($\lambda = 1$). For realization of $v \leq v^*$, all investors stay ($\lambda = 0$). The* *threshold v^* is characterized by*

$$\frac{1}{1+r+\sigma v^*} = \bar{p}_1 g(\mathcal{L}) \tag{6}$$

where $g(\mathcal{L})$ decreases in $\mathcal{L}$, $\lim_{\mathcal{L}\to 1} g(\mathcal{L}) = 1$, and is the unique solution to

$$\mathcal{L}\left(\mathcal{L} + \mathcal{L}\log\left(\frac{1}{g(\mathcal{L})\mathcal{L}}\right) - 1\right) - \left(\frac{1}{g(\mathcal{L})} - \mathcal{L}\right)\log\left(1 - \mathcal{L}g(\mathcal{L})\right) = 0. \tag{7}$$

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

Proof. See the Appendix A.2 □

Proposition 1 delivers the first sharp empirical prediction on investors' equilibrium behavior—the larger the interest rate shock, the higher the likelihood of fund run. We call this monetary-policy-induced fragility. The Equation 6 illustrates clearly the economic forces of such behavior. By re-writing (6), using the definition of the bond price for a given realized shock $p_1(v) = \frac{1}{1+r+\sigma v}$, and pre-multiplying on both sides the number of bonds $\frac{1}{p_0}$ the fund initially owns, all investors redeem in equilibrium if and only if

$$\frac{1}{p_0}\bar{p}_1 g(\mathcal{L}) > \frac{1}{p_0} p_1(v). \tag{8}$$

This condition is intuitive. It says that all investors redeem and hence the fund is completely liquidated when the NAV of the fund $\frac{1}{p_0}\bar{p}_1$, scaled up by a factor $g(\mathcal{L}) \geq 1$, is greater than the intrinsic value of the fund $\frac{1}{p_0}p_1(v)$. When the bond market is perfectly liquid ($\mathcal{L}$ approaches 1), the moderating factor $g(\mathcal{L})$ becomes 1. The condition boils down a simple arbitrage condition $\bar{p}_1 > p_1(v)$, saying that investors, who essentially observe the true value of the bond, redeem the shares whenever the NAV per unit of the bond is above the bond's value. When the liquidity of bond decreases, the moderating factor $g(\mathcal{L})$ increases, implying that investors redeem the shares in equilibrium even if the NAV is below the true value of the bond. This is because of the redemption externality discussed before. When the fund has to liquidate the bond at a discount to repay the redeeming investors, investors who stay have to incur the losses. Taking these losses into account, investors optimally choose to redeem for a larger range of realized interest rate shocks. Therefore, we henceforth refer $g(\mathcal{L})$ as the *coordination risk* factor.

Once the critical value of the interest rate shock v^* is pinned down, we can compute the ex-ante probability of the equilibrium in which all investors redeem, i.e., $\mathbb{P}(\tilde{v} > v^*)$. As in Chen, Goldstein, and Jiang (2010), we interpret this measure as the fragility of the fund.

2.3 Fragility in funds under different monetary policy environments

In this section, we study how fragility in bond mutual funds responds to different monetary policy environments and market liquidity conditions. The results of these analyses will give sharp empirical predictions of the model, which will be tested in Section 3.

We look at whether a more accommodating and/or uncertain monetary policy impacts financial fragility in the bond fund. In our model, a lower current interest rate r represents a looser monetary policy environment and higher volatility σ of the interest rate shock proxies for higher uncertainty in monetary policy.

Corollary 1 (Effects of monetary policy on fragility). *There exists a* $\tilde{\mathcal{L}} \in (0,1)$ *such that*

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

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

c. $\frac{\partial \mathbb{P}(\tilde{v}>v^*)}{\partial\sigma\partial(-r)} > 0$*;*

d. $\frac{\partial \mathbb{P}(\tilde{v}>v^*)}{\partial(-r)\partial(-\mathcal{L})} < 0$ *and* $\frac{\partial \mathbb{P}(\tilde{v}>v^*)}{\partial\sigma\partial(-\mathcal{L})} < 0.$

Proof. See the Appendix A.3. □

Corollary 1 contains predictions of the model. It first states that when the bond market is relatively liquid ($\mathcal{L} > \tilde{\mathcal{L}}$), a looser (lower r) and more uncertain (higher σ) monetary policy environment increases the fragility of bond funds. Then, the effects from the two distinct dimensions of monetary policy reinforce each other. Finally, bond illiquidity (lower $\mathcal{L}$) weakens such monetary-policy-induced fragility.

One can gain some insights on how the looseness of monetary policy affects financial fragility from the condition for fragility in (8). Intuitively, fragility is about how negative the realization of the shock v has to be, so that the realized bond price $p_1(v)$ is at least as high as the NAV (per bond) $\bar{p}_1$ scaled up by the coordination risk factor $g(\mathcal{L})$. Suppose for now the market is perfectly liquid, and thus $g(\mathcal{L}) = 1$. Consider a loosening of monetary policy, i.e., from a high-r to a low-r environment. The difference between the NAV (per bond) $\bar{p}_1$ and the bond price at the expected shock $p_1(0)$ becomes larger. This is due to Jensen's inequality and the fact that the bond price is more convex in the low-r environment. As a result, the threshold shock v^* that equalizes realized bond price $p_1(v)$ and the NAV $\bar{p}_1$ has to be more negative, implying a higher fragility $\mathbb{P}(\tilde{v} > v^*)$.

When the market is illiquid enough, i.e., $g(\mathcal{L})$ sufficient higher than 1, the result is reversed. In the high-r regime, the bond's sensitivity to the interest rate shock (duration) is low. Thus, the interest rate shock has to be very negative to push the bond price enough to be above the scaled-up NAV. In this case, the bond's higher duration in the low-r regime helps prevent fragility. Put differently, as the market becomes more illiquid, the fragility concern from coordination risk becomes more critical and counteracts the fragility arising from the Jensen's effect associated with loose monetary policy environment, that is, $\frac{\partial \mathbb{P}(\tilde{v} > v^*)}{\partial(-r)}$ becomes less positive when $\mathcal{L}$ decreases.

A similar intuition applies to an increase in monetary policy uncertainty σ. The effect of Jensen's inequality becomes stronger with higher uncertainty, and hence, the bond fund is more fragile in a more volatile monetary policy environment. The effect is weakened as the bond market becomes illiquid because the fragility induced by illiquidity counteracts the fragility arising from high monetary policy uncertainty. The result that low-r and high-σ reinforce each other's impact also follows intuitively from Jensen's effect.

2.4 Summary of main hypotheses

In summary, using the results from Proposition 1 and Corollary 1, we formulate the following testable hypotheses and test them in Section 3. Following Chen, Goldstein, and Jiang (2010) and Goldstein, Jiang, and Ng (2017), we proxy the existence of fragility with a positive outflow-to-interest-rate relationship and the increase of fragility with greater outflow-to-interest-rate sensitivity.

- *Hypothesis 1:* There is a positive relationship between fund outflows and interest rate shocks ("monetary-policy-induced fragility").
- *Hypothesis 2:* The outflow-to-interest-rate sensitivity is stronger in a looser monetary policy environment, when the market is relatively liquid ("monetary-policy-looseness-enhanced fragility").
- *Hypothesis 3:* The outflow-to-interest-rate sensitivity is stronger in a more uncertain monetary policy environment, when the market is relatively liquid ("monetary-policy-uncertainty-enhanced fragility").
- *Hypothesis 4:* There is a complementary effect on outflow-to-interest-rate sensitivity between looseness and uncertainty in monetary policy environment.
- *Hypothesis 5:* Bond illiquidity weakens both monetary-policy-looseness-enhanced fragility and uncertainty-enhanced fragility.

3 Data and Sample

3.1 Data

Corporate bond mutual funds. Monthly data on corporate bond mutual funds are extracted from the Center for Research in Security Prices (CRSP). The sample construction follows Goldstein, Jiang, and Ng (2017). The sample runs from January 1992 to December 2017.[8] The dataset contains monthly returns and total net asset (TNA) values for each fund share, as well as its detailed characteristics, such as fund expense ratios and fund types. We select corporate bond mutual funds based on their objective codes provided by CRSP.[9] Index corporate bond mutual funds, exchange-traded funds, and exchange-traded notes are excluded. We restrict the sample to fund shares with more than one-year history in the sample period. We further remove fund share-month entries without return or TNA information, and discard fund share-month entries with more than 100% increase or decrease in TNA over a month. Our final sample contains 5,414 unique fund shares.[10]

Daily fund flows. The data on daily flows at the fund share level is extracted from MorningStar Direct (MS). We merge MS data and CRSP data using ticker information following Berk and Van Binsbergen (2015), and keep corporate bond funds based on CRSP' objective codes. The sample runs from January 2009 to December 2017. Prior to 2009, the daily flows are largely missing. The daily sample contains 2,753 unique fund shares.

TFF rates. The U.S. Federal Reserve sets the TFF (TFF) rate, which is the rate at which depository institutions (banks) lend reserve balances to other banks on an overnight basis. We adopt TFF, extracted from Federal Reserve Economic Data (FRED), as a proxy for r.[11] We also extract the dates of FOMC meetings from Federal Reserve. Our sample covers a total of 312 months, among

[8] There are few corporate bond mutual funds in the database prior to 1991. The performance of each bond fund share is estimated using one year of data, so the data of 1991 is excluded.

[9] A mutual fund share is considered as 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 start with 'IC'.

[10] One bond fund can issue several shares, tailored to different customers. Although these fund shares have the same holdings and valuation, their varied characteristics, such as fees and investment horizons, can affect investors' purchase and redemption decisions, and hence, fund flows. So we use fund share as the unit of analysis.

[11] Before 2008, the TFF rate 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 TFF rate.

which 224 months have FOMC meetings.

Monetary policy uncertainty. Our main proxy for monetary policy uncertainty in the U.S. is the MPU index developed by Husted, Rogers, and Sun (2019), as shown in Figure 4. The MPU index (denoted as "MPU HRS") is constructed by counting keywords related to monetary policy uncertainty in the New York Times, Wall Street Journal and Washington Post. The MPU index spikes around near tight presidential elections, Taper Tantrum, QE1 and QE 2, the 9/11 attacks, and other periods featuring significant monetary policy disruptions.

Illiquidity. Following Goldstein, Jiang, and Ng (2017), we employ three proxies for the market-level corporate bond illiquidity, $-\mathcal{L}$. The first proxy is the corporate bond market illiquidity index proposed by Dick-Nielsen, Feldhütter, and Lando (2012) (DFL). This index is available from July 2002 to September 2017, which is shorter than our sample period. To avoid the loss of sample, we adopt the VIX index from the Chicago Board Options Exchange (CBOE) as our second measurement of corporate bond market illiquidity, which has 87.5% Pearson correlation with the DFL index. Bao, Pan, and Wang (2011) also confirm that the VIX index positively correlates with the illiquidity of corporate bonds. Third, Brunnermeier and Pedersen (2009) argue that funding liquidity of financial institutions positively affects market liquidity. We, therefore, use TED spread from FRED as the measure of funding illiquidity, which further influences the illiquidity of the corporate bond market.[12]

We further consider two fund share level measures for illiquidity, cash holdings, and cash and government bonds holdings recorded in CRSP. These two measures are endogenous to fund managers' liquidity management. Anticipating withdrawals, fund managers would hoard cash or liquid government bonds. However, such liquidity management does not affect our main predictions

[12] TED rate measures the difference between the three-month London Interbank Offered Rate and the three-month Treasury-bill interest rate.

because our strategic complementarities arise form interest rate risk instead of the fire sale cost.

Other variables. We consider potential macro drivers for fund flows to the corporate bond mutual funds, including the yield slope, the default spread, and the aggregate bond market illiquidity. The yield slope is calculated as the yield difference between the 30-year and one-year Treasury yields. The default spread is the yield difference between BBB- and AAA-rated corporate bonds, both extracted from FRED.

Measurement construction. The net fund flow of fund share i at month t is calculated as

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

where $R_{i,t}$ is the return of fund share i over month t, and $TNA_{i,t}$ is the end-of-month total net asset value.

The performance of fund i at month t is measured as the past one year's alpha from the following time-series regression:

$$R^e_{i,\tau} = \text{Perf}_{i,t-12\to t-1} + \eta_B R^e_{B,\tau} + \eta_M R^e_{M,\tau} + \varepsilon_{i,\tau}, \quad \tau \in (t-12, t-1) \tag{9}$$

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 1-month London Interbank Offered Rate (LIBOR). $R^e_{B,\tau}$ is approximated by the Vanguard total bond market index fund return from Bloomberg and $R^e_{M,\tau}$ is approximated by CRSP value-weighted market return.

3.2 Summary Statistics

Table 2 presents the summary statistics for the fund shares in our sample from January 1992 to December 2017. To mitigate the influence of outliers, we winsorize all fund share variables at the 1% quantile from each tail. The reported statistics are consistent with Table 1 in Goldstein, Jiang, and Ng (2017). The corporate bond mutual funds deliver an average positive monthly return of 0.40% and attract an average positive inflow of 1.03% per month. The average size of funds is $350.36 million, and the average age is 8.84 years. On average, the funds hold 3.06% cash in the portfolio, with a standard derivation of 10.71%. Both mean and median of Perf are positive, implying that the bond funds, on average, beat the market before the fees. The average regression loading on the aggregate bond market return, $\eta_B = 0.58$, is much higher than that on the stock market return, β_M. This suggests that the bond mutual fund returns only moderately co-move with the stock market and that the standard Capital Asset Pricing Model (CAPM) alone is not enough to approximate the wealth portfolio of bond investors.

4 Empirical Results

This section devotes to empirically testing hypotheses in section 2.4. We first provide association evidence using monthly data and then turn to daily data for sharp identification. The robustness check is in the last part.

4.1 Evidence from Panel Regressions

4.1.1 Monetary-policy-induced fragility

We start with testing Hypothesis 1, which predicts a positive outflow-to-interest-rate relationship for corporate bond mutual funds. As the TFF rate varies over time, we rely on panel regressions with fund fixed effects to exploit fund flows' response to the changes in TFF rate. We perform the following panel regression:

$$OutFlow_{i,t} = \alpha_i + \Delta\text{TFF}_t + \text{Controls}_t^M + \text{Controls}_{i,t}^F + \text{Controls}_t^I + \varepsilon_{i,t} \tag{10}$$

where $OutFlow_{i,t}$ measures the outflows from fund share i over month t and the key independent variable ΔTFF_t is the change in TFF rate over month t. To rule out the concern of omitted variables, we include potential macro-and micro-drivers for fund flows as control variables. Macro controls, Controls_t^M, include 1) the term-structure of corresponds bonds, approximated by the change in yield indifference between 30-year and 1-year Treasury yield, 2) the default risk, approximated by the change in yield difference between BBB- and AAA-rated corporate bonds, and 3) the bond market illiquidity, approximated by the change in VIX index.[13] Micro controls, $\text{Controls}_{i,t}^F$, are fund share characteristics at month t, including fund performance from regression (9), last month's fund return, natural log of the total net asset and expense ratio.[14] Lastly, since the model predictions are partial derivatives for a given set of exogenous parameters, we also include the indicator for market conditions $\mathbb{1}(\text{High MPU}^{HRS})$, $\mathbb{1}(\text{High VIX})$ as control variables. To allow for an intertemporal dependence of flows across funds and across time, we cluster standard errors at the fund share and month levels.

Columns (1)–(3) in Table 3 present the regression results with different specifications. Significant positive loadings on ΔTFF_t confirm the positive relationship between outflows and the TFF rate. Specifically, a 1% increase in the TFF rate is accompanied by 1.04% incremental outflows (roughly 18.85 billion USD benchmarked to the total size of corporate bond mutual funds in 2017). Moreover, there are more outflows from the corporate bond mutual funds when the default spread is higher, and the bond market is more illiquid. At the fund level, poor past performances and past returns drive the capital out from the funds.

Since the TFF rate is adjusted only after FOMC meetings, we conduct a robustness analysis in a subsample comprised of months with FOMC meetings only. Columns (4)–(6) in Table 3 confirm the strong positive outflow-to-interest-rate relationship. The effect sizes are slightly larger than

[13] Choi and Kronlund (2017) consider these three variables as potential macro drivers for reaching for yield in the corporate bond mutual funds.

[14] Since we already include fund fixed effect, we do not include fund age, which is a deterministic value in time series.

those in the first three columns. Overall, we find capital flows out from corporate bond mutual funds when the TFF rate increases. This is in line with Banegas, Montes-Rojas, and Siga (2016), who find positive monetary policy shocks trigger massive aggregate outflows from bond funds.

4.1.2 Monetary-policy-looseness-enhanced fragility

According to Hypothesis 2, when the bond market is relatively liquid, the fund fragility will be exacerbated in a low Fed fund rate regime compared with a high Fed fund rate regime because of the convexity in bond price. To test this hypothesis, we add interaction terms of low- versus high-interest-rate regime to the specification (10):

$$
\begin{aligned}
OutFlow_{i,t} = {} & \alpha_i * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) + \Delta\text{TFF}_t * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) + \text{Controls}_t^M * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \\
& + \text{Controls}_{i,t}^F * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) + \text{Controls}_t^I * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) + \varepsilon_{i,t} \quad \forall VIX_t < \overline{VIX_t},
\end{aligned}
\tag{11}
$$

where $\mathbb{1}(\text{Low}^T\ \text{TFF}_t)$ is an indicator variable that equals one if the TFF rate is below the bottom tercile and zero if it is above the top tercile over the sample period (see Figure 3), and other variables remain the same as before.[15] To ensure a relatively liquid market condition ($\mathcal{L} \to 1$), we consider a sub-sample when bond market illiquidity, measured by the VIX index, is below the sample mean. We include interaction terms for all control variables and fixed effects such that the estimation of interaction term $\Delta\text{TFF}_t * \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$ is unbiased. The standard errors are clustered at the fund share and month levels.

Table 4 presents test results. The coefficient loadings on $\Delta\text{TFF}_t * \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$ is of our interest, which measures the difference in outflow-to-interest-rate sensitivity (bond fund fragility) under low- v.s. high-interest-rate regimes. Significantly positive coefficients in all specifications suggest that the sensitivity of investors' redemption in response to a rise in interest rate increases in a lower Fed fund rate regime. In particular, during contractionary monetary policy periods, the

[15] We will address the concern that the TFF rate does not move from 2009 to 2015 in the section 4.3.

positive flow-to-interest-rate relationship is not significant; while during expansionary periods, a 1% increase in the TFF rate is associated with 4.52% (=3.74% + 0.78%) outflows (around 81.95 billion USD outflows benchmarked to the total size of corporate bond mutual funds in 2017), more than five times higher than that in the expansionary regime. These results are consistent with the model prediction that bond funds become more fragile in a lower-interest rate regime.

4.1.3 Monetary-policy-uncertainty-enhanced fragility

Hypothesis 3 predicts that in a relatively liquid market, the outflow-to-interest-rate sensitivity is greater when monetary policy uncertainty is higher. We test this hypothesis using a similar specification as in specification (11):

$$\begin{aligned} OutFlow_{i,t} = {} & \alpha_i * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) + \Delta\text{TFF}_t * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) + \text{Controls}_t^M * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) \\ & + \text{Controls}_{i,t}^F * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) + \text{Controls}_t^I * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) + \varepsilon_{i,t} \quad \forall VIX_t < \overline{VIX_t}, \end{aligned}$$

where $\mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$ is an indicator variable that equals one if MPU^{HRS} is above the top tercile and zero if it is below the bottom tercile over the sample period (see Figure 4), and all other details are the same before.

Table 5 presents the results of regressions. All specifications evince that the outflow-to-interest-rate sensitivity is significantly stronger in the periods with higher monetary policy uncertainty. Compare to the low-monetary policy uncertainty regime, a 1% increase in the TFF rate is associated with 1.00% incremental outflows, around 18.13 billion USD outflows benchmarked to the total size of corporate bond mutual funds in 2017. These results provide supporting evidence for Hypothesis 3.

4.1.4 Complementary effects of monetary-policy-looseness-enhanced and uncertainty-enhanced fragility

Extending the findings that both looseness and uncertainty of monetary policy contribute to bond fund fragility, we further show they two reinforce each other, as predicted by Hypothesis 4. We adopt a three-way interaction panel regression to test this hypothesis:

$$\begin{aligned}OutFlow_{i,t} = {} & \alpha_i * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) + \Delta\text{TFF}_t * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) \\ & + \text{Controls}_t^M * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) + \text{Controls}_{i,t}^F * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) \\ & + \text{Controls}_t^I * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS}) + \varepsilon_{i,t}.\end{aligned}$$

The regression results are shown in Table 6. The positive coefficients of $\Delta\text{TFF}_t * \mathbb{1}(\text{Low}^T\ \text{TFF}_t) * \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$ indicate that the outflows-to-interest-rate sensitivity is highest in the periods with a low TFF rate and high monetary policy uncertain. In these months, a 1% increase in TFF rate is associated with 3.38%(=10.08%-9.06%-5.66%+8.02%) outflows, around three times higher than the average effect (1.17%) reported in Table 3.

In a nutshell, the above three sets of results demonstrate the critical role of monetary policy in determining bond mutual fund fragility. These results raise concerns for unexpected consequences of monetary policy on the bond mutual fund industry.

4.1.5 The moderating role of illiquidity

Next, we study how the bond market illiquidity affects the monetary-policy-looseness-enhanced and uncertainty-enhanced fragility. The insight by Goldstein, Jiang, and Ng (2017) suggests that bond illiquidity intensifies strategic complementarities among redemption decisions for fund investors. Our model features that the fragility induced by illiquidity can counteract the fragility arising from loose and uncertain monetary policy, as shown in Hypothesis 5. These predictions are verified using three-way interaction regression:

$$\begin{aligned}
OutFlow_{i,t} = {} & \alpha_i * \mathbb{1}(\cdot) * \mathbb{1}(\text{High}^T \text{ Illiq}_t) + \Delta\text{TFF}_t * \mathbb{1}(\cdot) * \mathbb{1}(\text{High}^T \text{ Illiq}_t) \\
& + \text{Controls}_t^M * \mathbb{1}(\cdot) * \mathbb{1}(\text{High}^T \text{ Illiq}_t) + \text{Controls}_{i,t}^F * \mathbb{1}(\cdot) * \mathbb{1}(\text{High}^T \text{ Illiq}_t) \\
& + \text{Controls}_t^I * \mathbb{1}(\cdot) * \mathbb{1}(\text{High}^T \text{ Illiq}_t) + \varepsilon_{i,t},
\end{aligned} \tag{12}$$

where $\mathbb{1}(\cdot)$ is either $\mathbb{1}(\text{Low}^T \text{ TFF}_t)$ or $\mathbb{1}(\text{High}^T \text{ MPU}_t^{HRS})$. $\mathbb{1}(\text{High}^T \text{ Illiq}_t)$ is an indicator variable that equals one if the market illiquidity measure is above the top tercile and zero if it is below the bottom tercile over the sample period. We adopt three proxies for market illiquidity—VIX index, DFL index by Dick-Nielsen, Feldhütter, and Lando (2012) and TED spread.[16] All other details are the same as in Equation (11).

Table 8 and A.2 shows the results. As predicted, the coefficient loadings for $\Delta\text{TFF}_t * \mathbb{1}(MP_t) * \mathbb{1}(\text{High}^T \text{ Illiq}_t)$ are all significantly negative, indicating that bond market illiquidity weakens monetary-policy-looseness-enhanced and uncertainty-enhanced fragility. The economic effects are huge. For example, in months with high VIX and low TFF rate, the change in TFF rate is weakly associated with outflow (a 1% increase in TFF rate is correlated with 0.1% (=-5.02%+2.60%+1.91%+0.61%) insignificant outflows); while the average effect in low-interest-rate regime is 4.52% as reported in Table 4. Therefore, the market illiquidity wipes out fragility enhanced by monetary policy looseness. Similarly, in months with high VIX and high monetary policy uncertainty, a 1% increase in TFF rate is associated with 0.94% (=-5.72%+4.88%+4.63%-2.85%) outflows, much smaller than the average effect of 2.79% reported in Table 5.

Since the bond illiquidity can be measured at the bond fund share level, we further improve our analysis by exploiting cross-sectional variations in bond illiquidity. We replace market-level illiquidity measurement by cash holdings or cash/government bond holdings at the fund share

[16] As the TED spread and the TFF rate is correlated, the regression with $\mathbb{1}(\text{Low}^T \text{ TFF}_t) * \mathbb{1}(\text{High}^T \text{ TED}_t)$ has missing coefficients on the three-way interactions. In this scenario, I replace $\mathbb{1}(\text{High}^T \text{ TED}_t)$ by $\mathbb{1}(\text{High}^M \text{ TED}_t)$, which equals one if the TED spread is above the sample mean, and zero otherwise.

level in regression (12), and include month$\times$fund objective fixed effects. The regression compares outflows to fund shares within the same objective code yet with different illiquidity level in response to the change in TFF between high- versus low-interest-rate (or monetary policy uncertainty) environment.

Table 9 depict the results. The attenuating effect of illiquidity is still conspicuous for looseness-enhanced fragility under such restricted comparison, while the effect is less evident for uncertainty-enhanced fragility. One possible explanation is that the convexity incremental in bond price is more prominent moving from a high- to a low-interest-rate regime, compared to ranging from a low- to a high-monetary policy uncertainty regime. Moreover, it is relatively hard for investors to gauge monetary policy uncertainty. Indeed, the effects for looseness-enhanced fragility in Table 4 are much stronger than uncertainty-enhanced fragility in Table 5.

4.1.6 Subsample analysis

Since the classification of high- versus low- interest-rate regime is rough, one may concern that other factors drive our results. For example, the heterogeneity in investors (institutional versus retail investors) may change in different interest rate regimes. Their distinct investment preferences can cause inflows (outflows) to corporate bond mutual funds. Alternatively, bond issuances vary in different interest rate regimes. Low-quality firms can take advantage of cheap financing during expansionary monetary policy periods by issuing more junk bonds.

To understand our findings better, we re-examine hypotheses 1,2,3 across subsamples of high- and low-yield funds, and institutional- and retail-oriented funds, see results in Table 10. The results on monetary-policy-induced fragility (columns (1)–(4)) are consistent with Table 3 to a great extent except for column (3). We believe the weak effect of institutional-oriented funds arises from their inflexibility in investment and redemption decisions. Put differently, institutional investors bear some cost in adjusting portfolios, so they are inertial to respond to monetary policy shocks. Regarding looseness-enhanced and uncertainty-enhanced fragility, the effects concentrate on low-yield funds and institutional-oriented funds. These results are intuitive. For low-yield bonds, their prices are more sensitive to the TFF rate changes than high-yield ones whose prices heavily depend on default risk. For institutional-oriented funds, their investors, facing a cost of adjusting portfolio, trade on monetary policy shocks only if there are enough trading gains to cover the cost. Clearly, the gains are much higher in a lower-interest-rate (higher-uncertainty) regime than a higher (lower-uncertainty) one, and hence, we observe a significant difference in their responses to monetary policy shocks between two regimes.

In summary, all above analyses evince that loose monetary policy and high monetary policy uncertainty can accentuate corporate bond mutual fund fragility, and market illiquidity can attenuate these effects.

4.2 Evidence from Event Studies

Although the above analyses provide supporting evidence for all our hypotheses, monthly regressions do not reveal a causal link between monetary policy and corporate bond mutual fund fragility. In this section, we sharpen the identification using the event study methodology. The TFF rate is announced on FOMC meetings, normally occurring every seven weeks or so. By investigating outflows (inflows) to fund shares over a narrow window before FOMC meetings, we can pinpoint the direct impact of monetary policy on fund fragility.

We extract daily fund flows from MorningStar Direct and run the event study to test Hypothesis 1 as follows:

$$OutFlow_{i,d+\tau_1\rightarrow d+\tau_2} = \alpha_i + \Delta\text{FF}_{d-1\rightarrow d+1} + \text{Controls}^M_{d-1\rightarrow d+1} + \text{Controls}^F_{i,t} + \text{Controls}^I_d + \varepsilon_{i,d}, \quad (13)$$

where $OutFlow_{i,d+\tau_1\rightarrow d+\tau_2}$ is the cumulative daily flows of fund share i from day $d+\tau_1$ to $d+\tau_2$ for the FOMC meeting on day d, and $\Delta\text{FF}_{d-1\rightarrow d+1}$ is the change of effective Fed funds (FF) rate over [-1,1] around the FOMC meeting on day d. Macro controls are constructed the same as $\Delta FF_{d-1\to d+1}$. The standard errors are clustered at the fund share and FOMC meeting levels.

According to our model, investors make investment or redemption decisions right before FOMC meetings. To capture this feature, we consider a five-day window *before* each FOMC meeting, that is, $[\tau_1, \tau_2] = [-5, -1]$. Moreover, we approximate investors' signals on the future change of r by the FF rate change over a one-day window around FOMC meetings.[17]

Table 11 presents the results. Columns (1)–(2) report significantly positive loadings on $\Delta FF_{d-1\to d+1}$, suggesting that investors withdraw (invest) capital from the funds if receiving positive (negative) signals on the change of rate announced by near FOMC meetings. The coefficient magnitudes are close to those reported in Table 3: a 1% increase in FF rate leads to 0.93% outflows within a five-day window before FOMC meetings. However, when we move the window of calculating outflows five-day ahead, over [-10, -6], the significant positive coefficients are gone; see columns (3)–(4). To further highlight the critical role of FOMC meetings, we run regressions with daily outflows on daily change of FF rates. Results in Table A.1 do not reveal any relationship between the two. Such precise timing ensures that our results are not driven by factors other than monetary policy. We can safely confirm a direct effect of monetary policy on fund fragility, consistent with our Hypothesis 1.

We extend the event study methodology to test Hypothesis 2 and present the results in Table 11. The regressions reveal much stronger investors' responses to monetary policy shock in low- versus high-interest-rate regime, confirming our Hypothesis 2. Additionally, using the illiquidity measure at the fund share level, we further confirm that illiquidity weakens monetary policy looseness-enhanced fragility; see Table 13.[18]

Overall, the event studies provide clear causal evidence on monetary policy' impacts on bond

[17] We adopt $\Delta FF_{d-1\to d+1}$ to avoid non-moving TFF rates over 2009 and 2014.

[18] Since monetary policy uncertainty is not resolved before the FOMC meetings, we do not adopt the event study method to test uncertainty-related predictions. Moreover, we do not push for other three-way interaction results due to the short sample of daily data.

fund fragility, complementing our monthly evidence in the previous section.

4.3 Robustness Checks

One concern of our monthly analysis is that the zero-interest-rate era from 2009 to 2014 accounts for a big proportion of the low-interest-rate regime; see Figure 3. As the TFF rate does not move in the zero-interest era, the results in the low-interest-rate regime are identified mainly by a few months with positive changes in TFF rates. To eliminate this concern, we limit the sample from January 1992 to December 2008, re-classify all the regimes within the sub-sample, and re-do all analyses related to interest-rate regimes. The results are presented in Table A.3 to Table A.7. Our results remain similar in all tables.

5 Conclusion

Since the financial crisis of 2008, the Federal Reserve has been actively maintaining a low federal fund target rate to ease the financing conditions of the real sector. Nevertheless, academics and regulators have voiced concerns regarding various potential negative consequences of the expansionary monetary policy. In this paper, we first showcase that monetary policy risk can be a source of fragility in an increasingly important part of the intermediation system, namely, the corporate bond mutual fund sector. Then, we demonstrate that loose and uncertain monetary policy environments can further exacerbate such fragility. These findings highlight understudied negative consequences of monetary policy, and call for the central bank's attention to internalize these effects in order to limit financial instability caused by the monetary policy.

References

Adrian, Tobias, Arturo Estrella, and Hyun Song Shin. 2019. "Risk-taking channel of monetary policy." *Financial Management* 48 (3):725–738. 6

Adrian, Tobias and Hyun Song Shin. 2008. "Financial Intermediaries, Financial Stability, and Monetary Policy." *FRB of New York staff report* (346). 7

Adriana, Tobias and Nellie Liangb. 2018. "Monetary Policy, Financial Conditions, and Financial Stability." *International Journal of Central Banking* . 6

Banegas, Ayelen, Gabriel Montes-Rojas, and Lucas Siga. 2016. "Mutual Fund Flows, Monetary Policy and Financial Stability." *Finance and Economics Discussion Series* 2016 (071):1–58. 6, 23

Bao, Jack, Jun Pan, and Jiang Wang. 2011. "The Illiquidity of Corporate Bonds." *The Journal of Finance* 66 (3):911–946. 19

Berk, Jonathan B and Jules H Van Binsbergen. 2015. "Measuring Skill in the Mutual Fund Industry." *Journal of Financial Economics* 118 (1):1–20. 18

Brunnermeier, Markus K and Lasse Heje Pedersen. 2009. "Market Liquidity and Funding Liquidity." *Review of Financial Studies* 22 (6):2201–2238. 19

Chen, Qi, Itay Goldstein, and Wei Jiang. 2010. "Payoff Complementarities and Financial Fragility: Evidence from Mutual Fund Outflows." *Journal of Financial Economics* 97 (2):239–262. 5, 6, 10, 15, 17

Choi, Jaewon and Mathias Kronlund. 2017. "Reaching for Yield in Corporate Bond Mutual Funds." *Review of Financial Studies* 17:63–36. 7, 22

Di Maggio, Marco and Marcin Kacperczyk. 2017. "The Unintended Consequences of the Zero Lower Bound Policy." *Journal of Financial Economics* 123 (1):59–80. 7

Dick-Nielsen, Jens, Peter Feldhütter, and David Lando. 2012. "Corporate Bond Liquidity before and after the Onset of the Subprime Crisis." *Journal of Financial Economics* 103 (3):471–492. 3, 19, 26, 36, 44, 45, 2, 6

Feroli, Michael, Anil K Kashyap, Kermit L Schoenholtz, and Hyun Song Shin. 2014. "Market Tantrums and Monetary Policy." *SSRN Electronic Journal* . 6

Friewald, Nils, Christian Wagner, and Josef Zechner. 2014. "The Cross-Section of Credit Risk Premia and Equity Returns." *The Journal of Finance* 69 (6):2419–2469. 1

Goldstein, Itay. 2017. "Comment on "Redemption risk and cash hoarding by asset managers" by Morris, Shim, and Shin ." *Journal of Monetary Economics* 89:88–91. 5

Goldstein, Itay, Hao Jiang, and David T Ng. 2017. "Investor Flows and Fragility in Corporate Bond Funds." *Journal of Financial Economics* 126 (3):592–613. 1, 3, 6, 10, 17, 19, 20, 25

Goldstein, Itay and Ady Pauzner. 2005. "Demand-Deposit Contracts and the Probability of Bank Runs." *The Journal of Finance* 60 (3):1293–1327. 13, 51

Husted, Lucas, John Rogers, and Bo Sun. 2019. "Monetary policy uncertainty." *Journal of Monetary Economics* . 19, 35, 42, 43, 47, 2, 5, 6

Ivashina, Victoria and Bo Becker. 2015. "Reaching for Yield in the Bond Market." *The Journal of Finance* 70 (5):1863–1902. 7

Liu, Xuewen and Antonio S Mello. 2011. "The Fragile Capital Structure of Hedge Funds and the Limits to Arbitrage." *Journal of Financial Economics* 102 (3):491–506. 5

Morris, Stephen, Ilhyock Shim, and Hyun Song Shin. 2017. "Redemption Risk and Cash Hoarding by Asset Managers." *Journal of Monetary Economics* 89:71–87. 5

Morris, Stephen and Hyun Song Shin. 2003. "Global Games: Theory and Applications." *Advances in Economics and Econometrics* :56–114. 13, 52

———. 2015. "Risk Premium Shifts and Monetary Policy: a Coordination Approach ." *Princeton University William S. Dietrich II Economic Theory Center Research Paper* . 6

Schmidt, Lawrence, Allan Timmermann, and Russ Wermers. 2016. "Runs on Money Market Mutual Funds." *American Economic Review* 106 (9):2625–2657. 6

Topsok, Flemming. 2006. "Some Bounds for the Logarithmic Function." *Inequality Theory and Applications* 4:137. 54

Zeng, Yao. 2017. "A Dynamic Theory of Mutual Fund Runs and Liquidity Management." *SSRN Electronic Journal* . 5

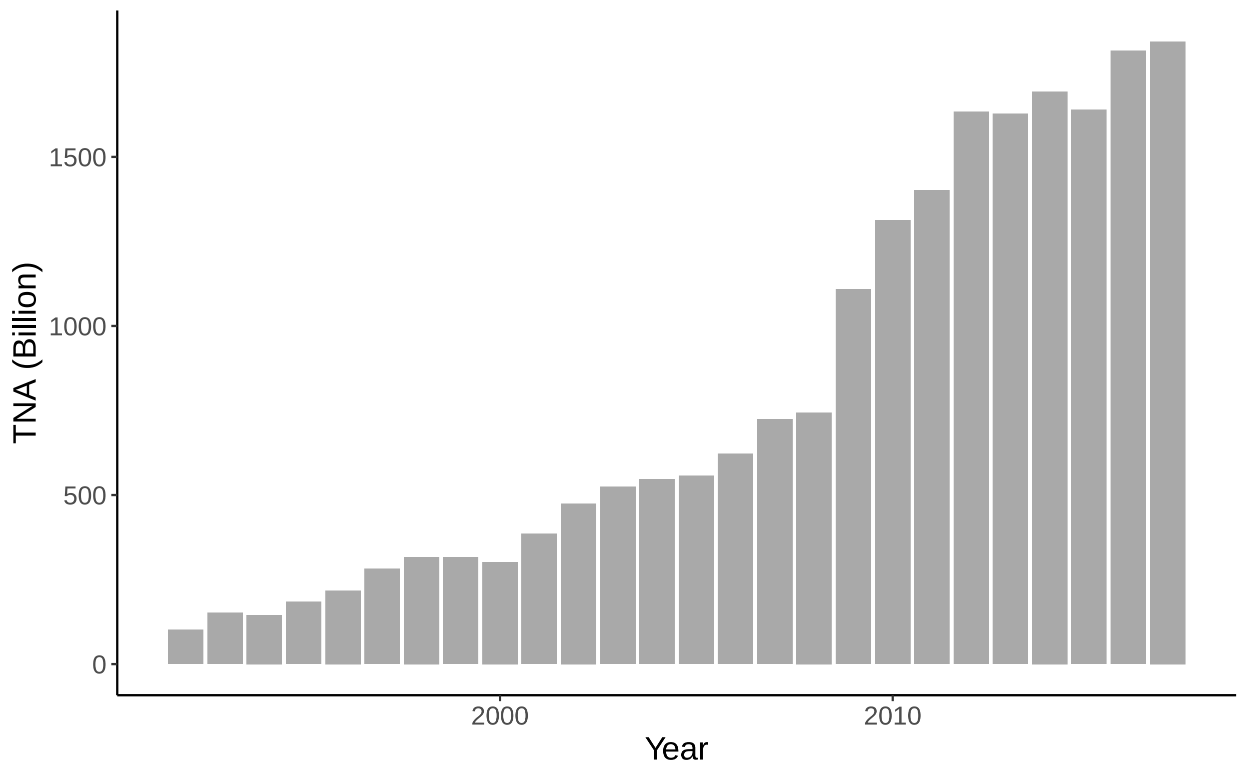

Figure 2: Total net asset of corporate bond mutual funds. This figure shows total net assets (TNA) of corporate bond mutual funds from January 1992 to December 2017. We exclude index corporate bond mutual funds, exchange traded funds, and exchange traded notes from the CRSP mutual fund database.

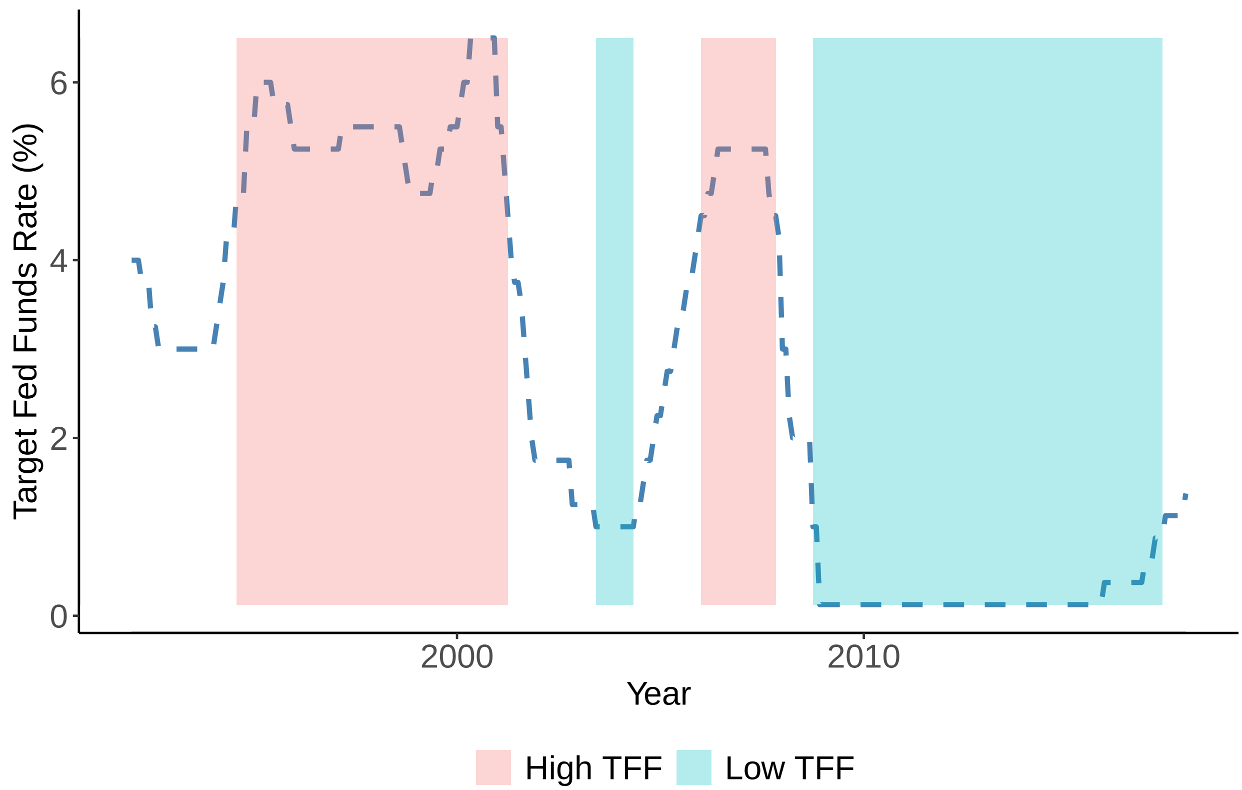

Figure 3: TFF rate and high and low Fed fund rate regimes. This figure plots the TFF rate from January 1992 to December 2017. The low (high) Fed fund rate regime corresponds to the periods when the TFF rate is below (above) the bottom (top) tercile.

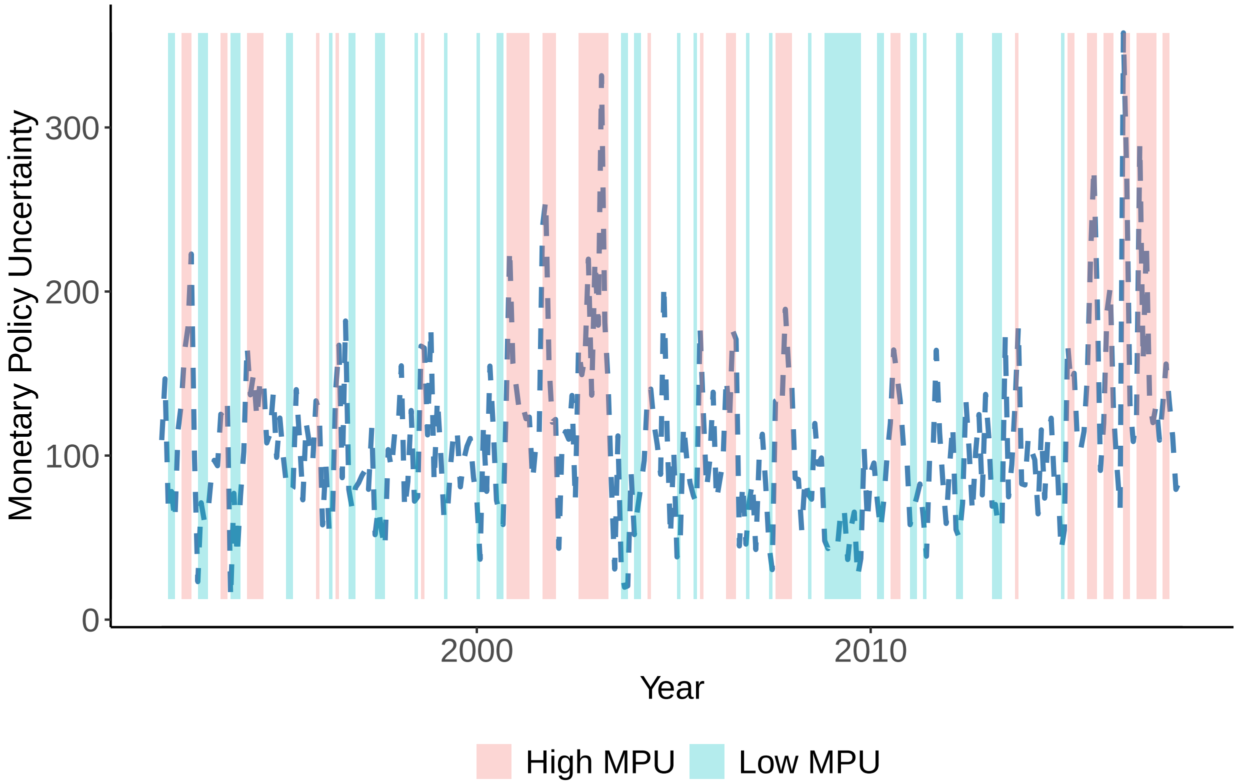

Figure 4: Monetary policy uncertainty index and high and low uncertainty regimes. There figures plot monthly monetary policy uncertainty index constructed by Husted, Rogers, and Sun (2019). "MPU HRS" is constructed based on keywords related to monetary policy uncertainty in the New York Times, Wall Street Journal and Washington Post. The high (low) monetary policy uncertainty regime corresponds to the periods when monetary policy uncertainty index is above (below) the top (bottom) tercile.

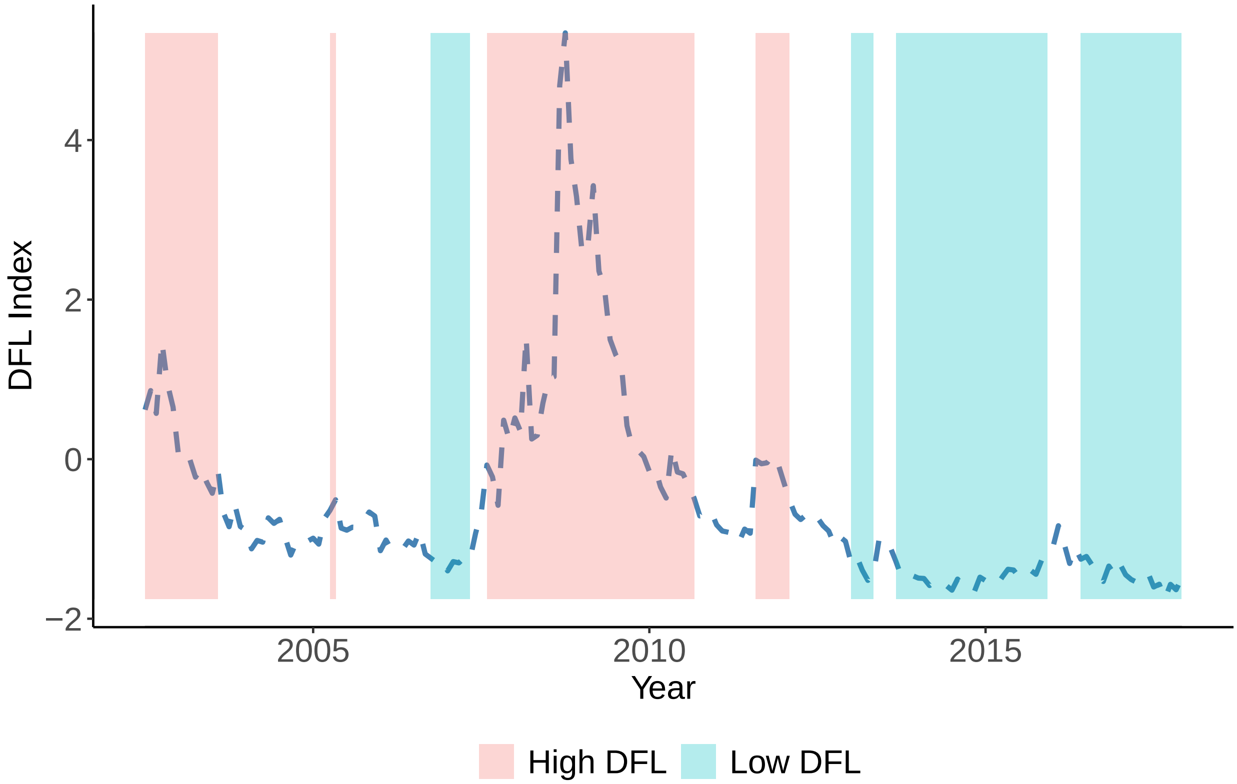

Figure 5: DFL index and high and low bond market illiquidity regimes. This figure plots the DFL index constructed by Dick-Nielsen, Feldhütter, and Lando (2012) from July 2002 to December 2017. The high (low) market illiquidity regime corresponds to the periods when the DFL index is above (below) the top (bottom) tercile.

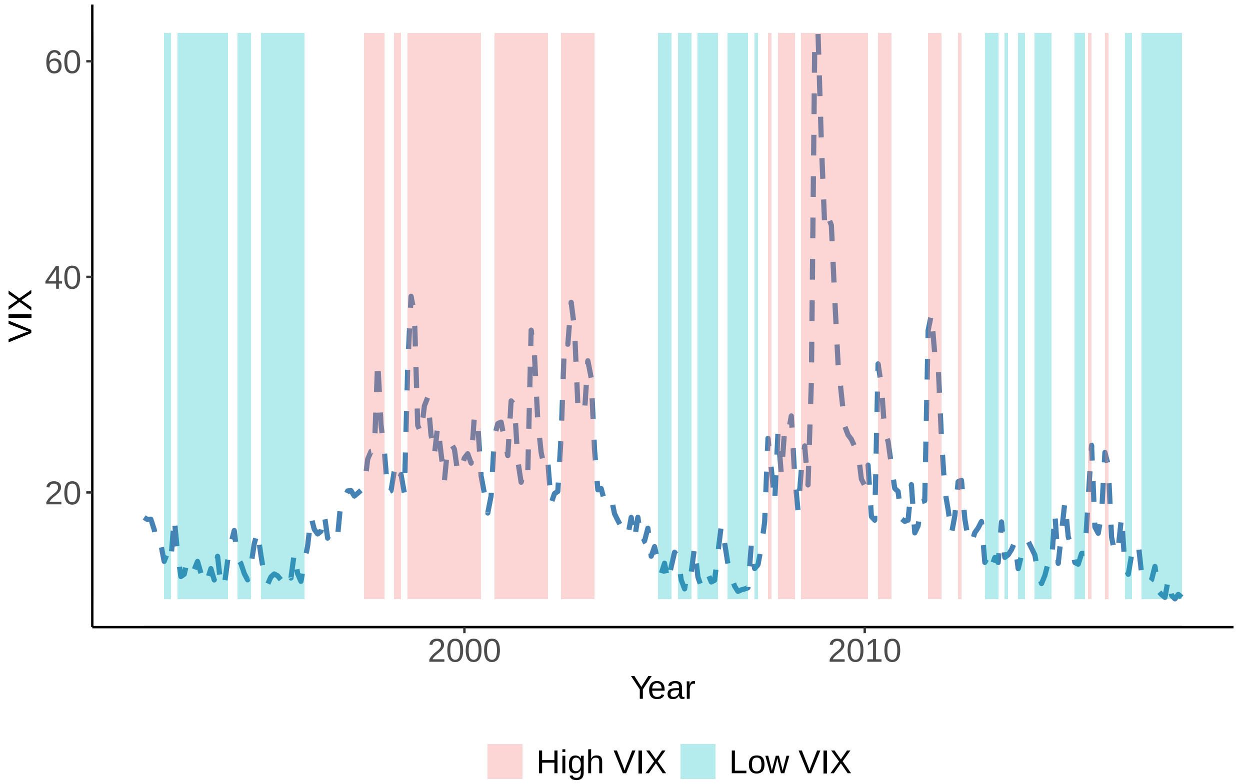

Figure 6: VIX index and high and low bond market illiquidity regimes. This figure plots the VIX index from January 1992 to December 2017. The high (low) market illiquidity regime corresponds to the periods when the VIX index is above (below) the top (bottom) tercile.

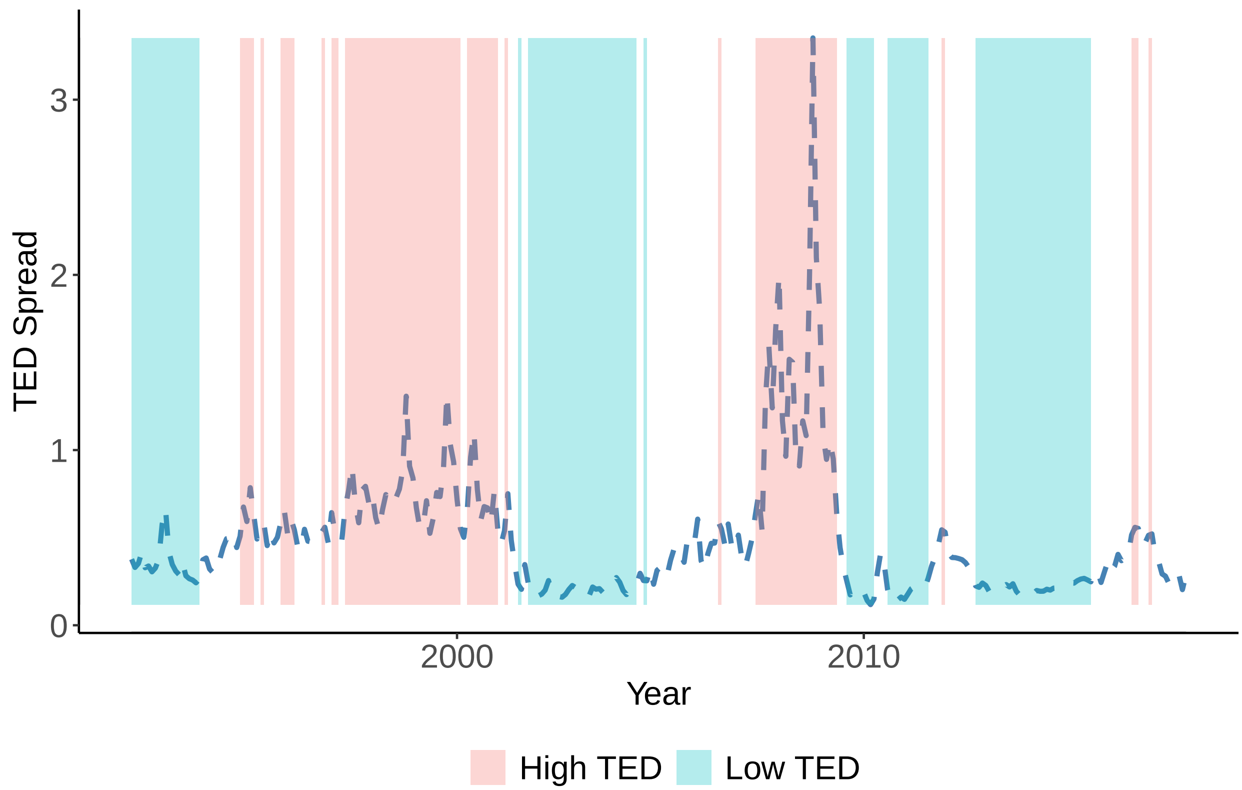

Figure 7: TED spread and high and low bond market illiquidity regimes. This figure plots the TED spread from January 1992 to December 2017. The high (low) market illiquidity regime corresponds to the periods when the TED spread is above (below) the top (bottom) tercile.

	Mean	Std Dev	P5	P25	Median	P75	P95	N
Flow (%)	1.033	8.383	-7.378	-1.617	-0.128	1.953	14.064	531,290
Return (%)	0.401	1.351	-1.896	-0.163	0.387	1.068	2.497	531,290
Log(TNA)	3.658	2.526	-1.204	2.116	3.923	5.439	7.424	531,290
Log(Age)	1.778	0.999	-0.122	1.170	1.922	2.531	3.155	531,290
Expense (%)	1.031	0.488	0.370	0.660	0.910	1.410	1.900	474,947
Cash Holding (%)	3.057	10.706	-12.560	0.150	2.350	5.550	19.460	446,705
Government Bond Holding (%)	11.273	17.087	0.000	0.000	0.540	18.710	48.940	446,705
Perf (%)	0.158	0.429	-0.537	-0.053	0.128	0.371	0.880	477,014
η_B	0.577	0.526	-0.161	0.262	0.569	0.867	1.439	477,014
η_M	0.113	0.163	-0.077	-0.002	0.058	0.206	0.439	477,014

Table 2: Summary statistics of fund characteristics. This table presents the summary statistics for characteristics of all corporate bond mutual funds in our sample from January 1992 to December 2017. The unit of analysis is fund share-month. Flow (%) is the fund flow in a given month in percentage point, Fund return (%) is the monthly net fund return in percentage point. TNA is the total net assets, Age is the fund age in years since its inception in the CRSP database. Expense (%) is fund expense ratio in percentage point. Cash Holdings is the proportion of fund assets held in cash in percentage point. Government Bond Holding is the proportion of fund assets held in government bonds in percentage point Perf, η_B, η_M are coefficients from regression (9) for each fund share. The sample includes 5,414 unique fund share classes and 1,888 unique funds. We exclude index corporate bond mutual funds, exchange-traded funds, and exchange-traded notes from the CRSP mutual fund database. To mitigate the influence of outliers, we winsorize all fund share variables at the 1% quantile from each tail.

	Dependent variable: $OutFlow_{i,t}$(%)					
	Full sample			Months with FOMC meetings		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔTFF$_t$	1.734***	1.134***	1.037***	1.740***	1.298***	1.173***
	(3.215)	(3.951)	(3.300)	(3.199)	(3.944)	(3.318)
ΔYield slope$_t$		−0.173	−0.258		−0.103	−0.205
		(−0.663)	(−0.875)		(−0.295)	(−0.538)
ΔDefault spread$_t$		0.972**	0.991**		1.345***	1.307**
		(2.522)	(2.382)		(2.796)	(2.507)
ΔVIX$_t$		1.253***	1.319***		1.166***	1.240***
		(3.524)	(3.387)		(2.964)	(2.931)
$\mathbb{1}$(High^M VIX$_t$)		−0.875***	−1.210***		−0.752***	−1.096***
		(−7.472)	(−8.852)		(−5.370)	(−6.760)
$\mathbb{1}$(High^M MPU$_t^{HRS}$)		−0.172*	0.020		−0.138	0.051
		(−1.833)	(0.179)		(−1.181)	(0.373)
Perf$_{i,t-1}$		−115.196***	−91.663***		−109.149***	−84.754***
		(−7.969)	(−6.053)		(−6.660)	(−4.929)
$R_{i,t-1}$		−22.761***	−23.432***		−21.881***	−23.401***
		(−6.425)	(−6.222)		(−5.116)	(−5.141)
Log(TNA$_{i,t}$)		0.041***	0.055		0.041***	0.069
		(3.461)	(1.394)		(3.069)	(1.578)
Expense$_{i,t}$		56.576***	−167.053***		51.255***	−171.679***
		(6.554)	(−5.239)		(5.160)	(−4.875)
Constant		−0.564***			−0.573***	
		(−4.463)			(−3.785)	
Fund FE	Y	N	Y	Y	N	Y
Observations	531,290	444,762	444,762	372,473	311,476	311,476
Adjusted R^2	0.058	0.013	0.067	0.057	0.013	0.067

Table 3: Monetary-policy-induced fragility (Hypothesis 1) This table reports tests for the effect of monetary policy changes on fund flows of corporate bond mutual funds from January 1992 to December 2017. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. ΔTFF$_t$ is the change in the TFF rate in percentage point. Macro controls include the change in the yield slope, the default spread, and the VIX index. $\mathbb{1}$(High^M VIX$_t$) ($\mathbb{1}$(High^M MPU$_t^{HRS}$)) equals 1 if the VIX index (the MPU^{HRS} index) is above the sample average, and 0 others. Fund characteristics include past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	Dependent variable: $OutFlow_{i,t}$(%)			
	Sample with Low^M VIX		Months with FOMC meetings & Low^M VIX	
	(1)	(2)	(3)	(4)
$\Delta\text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	4.086***	3.536**	3.974**	3.737**
	(2.767)	(2.091)	(2.555)	(1.967)
ΔTFF_t	1.029	0.596	1.179	0.779
	(0.938)	(0.803)	(1.019)	(0.870)
$\text{Controls}_t^M \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	N	Y	N	Y
$\text{Controls}_{i,t}^F \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	N	Y	N	Y
$\text{Controls}_t^I \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	N	Y	N	Y
Fund FE $\times\mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	Y	Y	Y	Y
Observations	249,631	206,597	166,556	137,604
Adjusted R^2	0.122	0.111	0.121	0.108

Table 4: Monetary-policy-looseness-enhanced fragility (Hypothesis 2) This table reports tests for monetary-policy-looseness-enhanced fragility in a liquid market for corporate bond mutual funds from January 1992 to December 2017. The market is liquid if the VIX index is below the sample average. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. ΔTFF_t is the change in the TFF rate. $\mathbb{1}(\text{Low}^T\ \text{TFF}_t)$ equals 1 if the TFF rate is below the bottom tercile, and 0 if above the top tercile over the sample period. Controls_t^M are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicator includes $\mathbb{1}(\text{High}^M\ \text{MPU}_t^{HRS})$. $\text{Controls}_{i,t}^F$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	Dependent variable: $OutFlow_{i,t}$ (%)			
	Sample with Low^M VIX		Months with FOMC meetings & Low^M VIX	
	(1)	(2)	(3)	(4)
$\Delta\text{TFF}_t \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	0.930**	2.336***	0.819*	1.003**
	(2.109)	(5.359)	(1.672)	(2.102)
ΔTFF_t	1.283***	0.039	1.527***	1.791***
	(3.040)	(0.097)	(3.191)	(3.682)
$\text{Controls}_t^M \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	N	Y	N	Y
$\text{Controls}_{i,t}^F \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	N	Y	N	Y
$\text{Controls}_t^I \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	N	Y	N	Y
Fund FE $\times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	Y	Y	Y	Y
Observations	205,845	171,529	140,730	116,622
Adjusted R^2	0.105	0.109	0.103	0.111

Table 5: Monetary-policy-uncertainty-enhanced fragility (Hypothesis 3) This table reports tests for monetary-policy-uncertainty-enhanced fragility in a liquid market for corporate bond mutual funds from January 1992 to December 2017. The market is liquid if the VIX index is below the sample average. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. ΔTFF_t is the change in the TFF rate. $\mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$ equals 1 if the MPU^{HRS} index by Husted, Rogers, and Sun (2019) is above the top tercile, and 0 if below the bottom tercile over the sample period. Controls_t^M are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicator includes $\mathbb{1}(\text{Low}^M\ \text{TFF}_t)$. $\text{Controls}_{i,t}^F$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	Dependent variable: $OutFlow_{i,t}$(%)			
	Full Sample		Months with FOMC meetings	
	(1)	(2)	(3)	(4)
$\Delta \text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	9.122***	5.413*	13.387***	10.083***
	(3.167)	(1.645)	(3.767)	(2.749)
$\Delta \text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	−7.086***	−3.982	−10.984***	−9.064***
	(−2.747)	(−1.262)	(−3.357)	(−2.631)
$\Delta \text{TFF}_t \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	−5.329**	−2.690	−9.167***	−5.659*
	(−2.003)	(−0.892)	(−2.749)	(−1.738)
ΔTFF_t	7.292***	4.126	11.176***	8.015**
	(2.838)	(1.331)	(3.428)	(2.456)
$\text{Controls}_t^M \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	N	Y	N	Y
$\text{Controls}_{i,t}^F \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	N	Y	N	Y
$\text{Controls}_t^I \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	N	Y	N	Y
Fund FE $\times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	Y	Y	Y	Y
Observations	278,575	230,572	192,049	158,523
Adjusted R^2	0.113	0.113	0.114	0.115

Table 6: Complementary effects of monetary-policy-looseness-enhanced and uncertainty-enhanced fragility (Hypothesis 4). This table reports tests for complementary effect of monetary-policy-looseness and uncertainty on fragility for corporate bond mutual funds from January 1992 to December 2017. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. TFF_t is the monthly TFF rate in percentage point and MPU_t^{HRS} is monthly monetary policy uncertainty index developed by Husted, Rogers, and Sun (2019). Low^T equals 1 if the corresponding variable is below the bottom tercile, and 0 if it is above the top tercile over the sample period; the opposite for High^T. Controls_t^M are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicator includes $\mathbb{1}(\text{High}^M\ \text{VIX}_t)$. $\text{Controls}_{i,t}^F$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

$\mathbb{1}(Illiq_t)$	Dependent variable: $OutFlow_{i,t}(\%)$					
	Full Sample with $\Delta TFF_t >= 0$			Months with FOMC meetings & $\Delta TFF_t >= 0$		
	$High^T$ VIX	$High^T$ TED	$High^T$ DFL	$High^T$ VIX	$High^T$ TED	$High^T$ DFL
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta TFF_t \times \mathbb{1}(Illiq_t)$	2.463**	0.663	2.651	2.590**	0.019	5.416***
	(2.062)	(0.398)	(1.368)	(2.023)	(0.010)	(2.645)
ΔTFF_t	0.948	1.327	2.912**	1.114	2.651	3.065**
	(1.264)	(0.926)	(2.456)	(1.334)	(1.612)	(2.215)
$Controls^M_t \times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y	Y	Y
$Controls^F_{i,t} \times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y	Y	Y
$Controls^I_t \times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y	Y	Y
Fund FE $\times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y	Y	Y
Observations	266,158	276,612	226,728	184,881	188,428	154,586
Adjusted R^2	0.116	0.096	0.121	0.118	0.099	0.122

Table 7: The effect of market illiquidity on monetary-policy-induced-fragility. This table reports tests for the effect of market illiquidity on monetary-policy-induced fragility for corporate bond mutual funds from January 1992 to December 2017. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. TFF_t, VIX_t, TED_t and DFL_t are monthly TFF rate in percentage point, monthly VIX index, TED spread, and bond market illiquidity index developed by Dick-Nielsen, Feldhütter, and Lando (2012), respectively. $High^T$ equals 1 if the corresponding variable is above the top tercile, and 0 if it is below the bottom tercile over the sample period. $Controls^M_t$ are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicators include $\mathbb{1}(Low^M\ TFF_t)$ and $\mathbb{1}(High^M\ MPU^{HRS}_t)$. $Controls^F_{i,t}$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

$\mathbb{1}(Illiq_t)$	Dependent variable: $OutFlow_{i,t}(\%)$					
	Full Sample			Months with FOMC meetings		
	High^T VIX	High^M TED	High^T DFL	High^T VIX	High^M TED	High^T DFL
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(Illiq_t)$	−3.794	−6.463***	−2.387***	−5.021**	−5.981*	−4.054**
	(−1.590)	(−2.939)	(−2.601)	(−2.251)	(−1.954)	(−2.511)
$\Delta \text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	2.170	3.791**		2.597	2.721	
	(1.039)	(2.174)		(1.412)	(1.142)	
$\Delta \text{TFF}_t \times \mathbb{1}(Illiq_t)$	1.700	−0.204	−0.216	1.906	−1.449	0.833
	(1.203)	(−0.176)	(−0.142)	(1.333)	(−0.753)	(0.418)
ΔTFF_t	0.521	1.784**	3.425**	0.608	3.048*	3.750***
	(0.526)	(1.965)	(2.563)	(0.584)	(1.713)	(2.642)
$\text{Controls}_t^M \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y	Y	Y
$\text{Controls}_{i,t}^F \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y	Y	Y
$\text{Controls}_t^I \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y	Y	Y
Fund FE $\times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y	Y	Y
Observations	208,373	337,918	188,436	145,015	232,260	130,315
Adjusted R^2	0.144	0.112	0.147	0.144	0.116	0.145

Table 8: The effect of market illiquidity on monetary-policy-looseness-enhanced fragility (Hypothesis 5). This table reports tests for the effect of market illiquidity on monetary-policy-looseness-enhanced fragility for corporate bond mutual funds from January 1992 to December 2017. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. TFF_t, VIX_t, TED_t and DFL_t are monthly TFF rate in percentage point, monthly VIX index, TED spread, and bond market illiquidity index developed by Dick-Nielsen, Feldhütter, and Lando (2012), respectively. High^M (High^T) equals 1 if the corresponding variable is above the average (the top tercile), and 0 if it is below the average (the bottom tercile) over the sample period. Controls_t^M are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicator includes $\mathbb{1}(\text{High}^M\ \text{MPU}_t^{HRS})$. $\text{Controls}_{i,t}^F$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

$\mathbb{1}(Illiq_{i,t})$	Dependent variable: $OutFlow_{i,t}$(%)			
	Months with FOMC meetings & ΔTFF$_t$ >= 0		Months with FOMC meetings	
	Low^T Cash	Low^T CashBond	Low^T Cash	Low^T CashBond
	(1)	(2)	(3)	(4)
ΔTFF$_t \times \mathbb{1}(Illiq_t)$	−0.568	0.796**	0.369	1.107***
	(−1.365)	(1.960)	(0.796)	(2.587)
ΔTFF$_t \times \mathbb{1}$(Low^T TFF$_t$) $\times \mathbb{1}(Illiq_t)$			−1.736***	−2.368***
			(−2.806)	(−3.901)
Controls$^F_{i,t} \times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y
Fund FE $\times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y
Controls$^F_{i,t} \times \mathbb{1}(\cdot) \times \mathbb{1}(Illiq_t)$	Y	Y	N	N
Fund FE $\times \mathbb{1}(\cdot) \times \mathbb{1}(Illiq_t)$	Y	Y	N	N
Month $\times$ FundObj	Y	Y	Y	Y
Observations	168,668	167,959	139,543	138,721
Adjusted R^2	0.140	0.141	0.156	0.157

Table 9: The effect of bond fund illiquidity on monetary-policy-induced and monetary-policy-looseness-enhanced fragility (Hypothesis 5). This table reports tests for the effect of fund illiquidity on monetary-policy-induced and looseness-enhanced fragility for corporate bond mutual funds from January 1992 to December 2017. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. ΔTFF$_t$ is the change in the TFF rate. Cash (CashBond) is cash holdings (cash and government bonds holdings) at the fund share and month levels. Low^T equals 1 if the corresponding variable is below the bottom tercile, and 0 if it is above the top tercile over the sample period; the opposite for High^T. Controls$^F_{i,t}$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. FundObj is lipper objective code. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share level. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	Dependent variable: $OutFlow_{i,t}$(%)											
	Months with FOMC meetings				Months with FOMC meetings & Low^M VIX							
Sub-sample indicator	High yield	Low yield	Inst fund	Retail fund	High yield	Low yield	Inst fund	Retail fund	High yield	Low yield	Inst fund	Retail fund
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔTFF_t	1.735**	0.819***	0.449	1.507***	2.804	0.138	0.664	0.923	3.676***	0.209	−0.994	3.239***
	(2.529)	(2.706)	(1.218)	(3.692)	(1.641)	(0.206)	(0.861)	(0.811)	(4.744)	(0.333)	(−0.916)	(6.235)
$\Delta\text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$					4.529	2.648**	2.858*	4.415				
					(1.405)	(1.981)	(1.797)	(1.614)				
$\Delta\text{TFF}_t \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$									0.393	1.823***	2.880***	0.011
									(0.517)	(2.954)	(2.689)	(0.022)
Controls_t^M	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
$\text{Controls}_{i,t}^F$	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls_t^I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fund FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
$\text{Controls}_t^M \times \mathbb{1}(\cdot)$	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
$\text{Controls}_{i,t}^F \times \mathbb{1}(\cdot)$	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
$\text{Controls}_t^I \times \mathbb{1}(\cdot)$	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Fund FE $\times\mathbb{1}(\cdot)$	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Observations	100,334	211,142	114,911	192,250	43,876	93,728	56,285	79,345	36,865	79,757	45,731	68,371
Adjusted R^2	0.072	0.074	0.052	0.082	0.109	0.115	0.079	0.128	0.110	0.119	0.083	0.129

Table 10: Monetary-policy-looseness and uncertainty-enhanced fragility in sub-samples (Hypotheses 1,2). This table repeat tests of Table 4 and 5 for sub-samples of corporate bond mutual funds from January 1992 to December 2017. The sub-sample is split by high- (low-) yield funds or institutional (retail) funds. The market is liquid if the VIX index is below the sample average. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. TFF_t and MPU_t^{HRS} are the TFF rate in percentage point and MPU^{HRS} monetary policy uncertainty index developed by Husted, Rogers, and Sun (2019) at month t, respectively. Low^T equals 1 if the corresponding variable is below the bottom tercile, and 0 if it is above the top tercile over the sample period; the opposite for High^T. Controls_t^M are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicators include $\mathbb{1}(\text{Low}^M\ \text{TFF}_t)$ and $\mathbb{1}(\text{High}^M\ \text{MPU}_t^{HRS})$. $\text{Controls}_{i,t}^F$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

Window $[\tau_1, \tau_2]$	Dependent variable: $OutFlow_{i,d+\tau_1\rightarrow d+\tau_2}$(%)			
	[-5,-1]		[-10,-6]	
	(1)	(2)	(3)	(4)
$\Delta \text{FF}_{d-1\rightarrow d+1}$	1.256***	0.927***	0.118	−0.284
	(3.102)	(2.718)	(0.640)	(−1.283)
$\Delta \text{Yield slope}_{d-1\rightarrow d+1}$		0.199		−0.080
		(0.932)		(−0.332)
$\Delta \text{Default spread}_{d-1\rightarrow d+1}$		1.512*		1.625**
		(1.942)		(2.409)
$\Delta \text{VIX}_{d-1\rightarrow d+1}$		−0.362**		−0.015
		(−2.080)		(−0.089)
$\mathbb{1}(\text{High}^M\ \text{VIX}_d)$		−0.073		−0.155***
		(−1.218)		(−2.963)
$\mathbb{1}(\text{High}^M\ \text{MPU}_t^{HRS})$		0.111**		0.114***
		(2.429)		(2.632)
$\text{Log}(\text{TNA}_{i,t})$		0.029**		0.020
		(1.999)		(1.398)
$\text{Expense}_{i,t}$		−57.227***		−33.394**
		(−3.302)		(−2.085)
Fund FE	Y	Y	Y	Y
Observations	121,948	115,718	122,066	115,827
Adjusted R^2	0.085	0.075	0.078	0.070

Table 11: Daily analysis of monetary-policy-induced fragility (Hypothesis 1). This table reports tests for the effect of monetary policy changes on fund flows of corporate bond mutual funds in a short window before FOMC meetings during January 2009 and December 2017. $OutFlow_{i,d+\tau_1\rightarrow d+\tau_2}$ is the cumulative fund outflow for fund share i during days [-5, -1] or [-10, -6] before each FOMC meeting. $\Delta \text{FF}_{d-1,d+1}$ is the change in the effective Fed funds rate during days [-1,1] for each FOMC meeting. Macro controls include the change in the yield slope, the default spread, and the VIX index, constructed similar to $\Delta \text{FF}_{d-1\rightarrow d+1}$. $\mathbb{1}(\text{High}^M\ \text{VIX}_d)$ ($\mathbb{1}(\text{High}^M\ \text{MPU}_t^{HRS})$) equals 1 if the daily VIX index (the monthly MPU^{HRS} index) is above the sample average, and 0 others. Fund characteristics include the monthly total net asset in log scale and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and FOMC meeting levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

Window $[\tau_1, \tau_2]$	Dependent variable: $OutFlow_{i,d+\tau_1,d+\tau_2}$ (%)			
	[-5,-1]		[-10,-6]	
	(1)	(2)	(3)	(4)
$\Delta FF_{d-1\to d+1} \times \mathbb{1}(\text{Low}^M\ \text{TFF}_d)$	2.768***	1.469***	1.113**	0.556
	(5.529)	(2.590)	(1.989)	(1.021)
$\Delta FF_{d-1\to d+1}$	0.486*	0.668*	−0.484***	−0.791***
	(1.793)	(1.856)	(−2.877)	(−5.043)
$\text{Controls}_d^M \times \mathbb{1}(\text{Low}^M\ \text{TFF}_d)$	N	Y	N	Y
$\text{Controls}_{i,t}^F \times \mathbb{1}(\text{Low}^M\ \text{TFF}_d)$	N	Y	N	Y
$\text{Controls}_t^I \times \mathbb{1}(\text{Low}^M\ \text{TFF}_d)$	N	Y	N	Y
Fund FE $\times \mathbb{1}(\text{Low}^M\ \text{TFF}_d)$	Y	Y	Y	Y
Observations	121,948	115,718	122,066	115,827
Adjusted R^2	0.098	0.087	0.092	0.079

Table 12: Daily analysis of monetary-policy-looseness-enhanced fragility (Hypothesis 2). This table reports tests for looseness-induced fragility for corporate bond mutual funds in a short window before FOMC meetings during January 2009 and December 2017. $OutFlow_{i,d+\tau_1\to d+\tau_2}$ is the cumulative fund outflow for fund share i during days [-5, -1] or [-10, -6] before each FOMC meeting. $\Delta FF_{d-1\to d+1}$ is the change in the Fed funds rate during days [-1,1] for each FOMC meeting. $\mathbb{1}(\text{Low}^M\ \text{TFF}_d)$ equals 1 if the daily TFF rate is below the sample mean, and 0 otherwise. Controls_d^M are macro controls, including the change in the yield slope, the default spread, and the VIX index, constructed similar to $\Delta FF_{d-1\to d+1}$. Market indicator includes $\mathbb{1}(\text{High}^M\ \text{MPU}_t^{HRS})$. $\text{Controls}_{i,t}^F$ are monthly fund characteristics, including the total net asset in log scale and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and FOMC meeting levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

$\mathbb{1}(Illiq_{i,t})$	Dependent variable: $OutFlow_{i,d-5\to d-1}$(%)			
	Low^M Cash	Low^M CashBond	Low^T Cash	Low^T CashBond
	(1)	(2)	(3)	(4)
$\Delta FF_{d-1\to d+1} \times \mathbb{1}(Low^M\ TFF_d) \times \mathbb{1}(Illiq_{i,t})$	−0.615*	−0.481	−0.460	−0.628*
	(−1.755)	(−1.568)	(−1.544)	(−1.786)
$\Delta FF_{d-1\to d+1} \times \mathbb{1}(Illiq_{i,t})$	−0.075	−0.157	−0.039	0.069
	(−0.509)	(−1.048)	(−0.269)	(0.482)
$Controls^F_{i,t} \times \mathbb{1}(Low^M\ TFF_d) \times \mathbb{1}(Illiq_{i,t})$	N	Y	N	Y
Fund FE $\times \mathbb{1}(Low^M\ TFF_d) \times \mathbb{1}(Illiq_{i,t})$	Y	Y	Y	Y
Month × FundObj	Y	Y	Y	Y
Observations	121,052	115,139	121,052	115,139
Adjusted R^2	0.191	0.175	0.194	0.177

Table 13: Daily analysis of the effects of bond fund illiquidity on monetary-policy-looseness-enhanced fragility (Hypothesis 5). This table reports tests for the effect of fund illiquidity on monetary-policy-looseness-enhanced fragility for corporate bond mutual funds in a short window before FOMC meetings during January 2009 and December 2017. $OutFlow_{i,d-5\to d-1}$ is the cumulative fund outflow for fund share i during days [-5, -1] before each FOMC meeting. $\Delta FF_{d-1\to d+1}$ is the change in the Fed funds rate during days [-1,1] for each FOMC meeting. TFF_d is daily TFF rate in percentage point. Cash (CashBond) is cash holdings (cash and government bonds holdings) at the fund share and month levels. Low^M equals 1 if the corresponding variable is below the sample average, and 0 otherwise. $Controls^F_{i,t}$ are fund characteristics, including the total net asset in log scale and expense ratios. FundObj is lipper objective code. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share level. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

Appendix

A Proofs

A.1 Lemma 1

Proof. In the liquid region $\lambda \leq \frac{\mathcal{L}p_1}{\bar{p}_1}$, the derivative of $\Delta\pi(\lambda)$ with respect with λ in Equation (4) is

$$\frac{\partial \Delta\pi(\lambda)}{\partial\lambda} = \frac{1}{p_0}\frac{\bar{p}_1 - p_1\mathcal{L}}{p_1\mathcal{L}(1-\lambda)^2} \geq 0.$$

The last inequality comes from the restriction that $\mathcal{L} \leq \frac{\bar{p}_1}{p_1} \leq 1$ in the intermediate region. In the illiquid region, the derivative of $\Delta\pi(\lambda)$ with respect with λ in Equation (4) is

$$\frac{\partial \Delta\pi(\lambda)}{\partial\lambda} = -\frac{1}{p_1}\frac{\mathcal{L}}{\lambda^2} \leq 0.$$

Moreover,

$$\Delta\pi(0) = \frac{1}{p_0}\left(\frac{\bar{p}_1}{p_1} - 1\right) < 0$$
$$\Delta\pi\left(\frac{\mathcal{L}p_1}{\bar{p}_1}\right) = \frac{1}{p_0}\frac{\bar{p}_1}{p_1} > 0$$
$$\Delta\pi(1) = \frac{1}{p_0}\frac{\mathcal{L}}{(1)} > 0$$

Therefore, there exist and only exist one $\hat{\lambda}$ such that $\Delta\pi(\hat{\lambda}) = 0$, and $\Delta\pi(\lambda) < 0$ when $\lambda < \hat{\lambda}$ and $\Delta\pi(\lambda) > 0$ when $\lambda > \hat{\lambda}$.

□

A.2 Proposition 1

Proof. This proof applied the standard global results in Goldstein and Pauzner (2005). The proof contains three steps. First, we proof there is a unique symmetric switching strategy, in which every investor redeems when $v > v^*$ and stays when $v < v^*$. Second, we show λ given v^* is uniformly distributed. Last, we solve the equilibrium threshold v^*.

Step 1 The net payoff $\Delta\pi(\lambda, v)$ has the function form:

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

This net payoff function has the following properties:

1) $\Delta\pi(\lambda, v)$ is continuous and non-increasing in $p_1 = \frac{1}{1+r+v}$ (non-decreasing in v) for all λ (state monotonicity).
2) There is a unique v^* solving $\int_0^1 \Delta\pi(\lambda, v)d\lambda = 0$ (strict Laplacian State Monotonicity).
3) Payoff function is continuous (continuity).
4) $\Delta\pi(\lambda, v)$ follows the single-crossing property: for each v, there exists a $\lambda^* \in (0, 1)$ such that $\Delta\pi(\lambda, v) > 0$ for all $\lambda > \lambda^*$ and $\Delta\pi(\lambda, v) < 0$ for all $\lambda < \lambda^*$.
5) There are upper and lower dominance regions such that there exist sun-spot equilibria when $v \in [\underline{v}, \bar{v}]$.

Given all five properties of $\Delta\pi(\lambda, v)$, Lemma 2.3 in Morris and Shin (2003) concludes that there is a unique equilibrium and it is in symmetric switching strategy around a critical value v^*, such that investors redeem when $v > v^*$ and stays when $v < v^*$.

Step 2 Conditional on observing a realized signal v^*, v has the following distribution

$$F_{v|s_i}(v|s_i = v^*) = \frac{\int_{-\infty}^{v^*} f(v)f_\varepsilon(\frac{v^*-v}{\sigma_\varepsilon})dv}{\int_{-\infty}^{\infty} f(v)f_\varepsilon(\frac{v^*-v}{\sigma_\varepsilon})dv}.$$

Given the switching strategy defined in Proposition 1, the proportion of investors redeeming given receiving a signal $s^{'}$ equals to λ:

$$\lambda = Pr(s_i > v^*|s^{'}) = Pr(s^{'} + \sigma_\varepsilon\varepsilon > v^*|s^{'}) = 1 - F_\varepsilon(\frac{v^* - s^{'}}{\sigma_\varepsilon})$$
$$\Rightarrow \quad s^{'} = v^* - \sigma_\varepsilon F_\varepsilon^{-1}(1 - \lambda)$$

We denote $G(\cdot|v^*)$ as the cumulative density function for λ given v^*. It can be derived by equaling the probability that a fraction less than λ and the probability that s is less than the s' defined above:

$$
\begin{aligned}
G(\lambda|v^*) &= F_{v|s_i}\Big(v^* - \sigma_\varepsilon F_\varepsilon^{-1}(1-\lambda)\Big| v^*\Big) \\
&= \frac{\int_{-\infty}^{v^*-\sigma_\varepsilon F_\varepsilon^{-1}(1-\lambda)} f(v) f_\varepsilon(\frac{v^*-v}{\sigma_\varepsilon}) dv}{\int_{-\infty}^{\infty} f(v) f_\varepsilon(\frac{v^*-v}{\sigma_\varepsilon}) dv} \\
&= \frac{\int_{F_\varepsilon^{-1}(1-\lambda)}^{\infty} f(v^* - \sigma_\varepsilon z) f_\varepsilon(z) dz}{\int_{-\infty}^{\infty} f(v^* - \sigma_\varepsilon z) f_\varepsilon(z) dz} \qquad z = \frac{v^* - v}{\sigma_\varepsilon} \\
\lim_{\sigma_\varepsilon \to 0} G(\lambda|v^*) &= \frac{\int_{F_\varepsilon^{-1}(1-\lambda)}^{\infty} f(v^*) f_\varepsilon(z) dz}{\int_{-\infty}^{\infty} f(v^*) f_\varepsilon(z) dz} \\
&= 1 - F_\varepsilon\Big(F_\varepsilon^{-1}(1-\lambda)\Big) \\
&= \lambda
\end{aligned}
$$

Therefore, the proportion of investors redeeming λ given switching threshold v^* is uniformly distributed over [0,1], that is, $f_{\lambda|v^*} = 1$.

Step 3 In the equilibrium, the marginal investor receiving signal v^* is indifference between investing in the fund and the bank, that is, $\int_\lambda \Delta\pi(\lambda) f_{\lambda|v^*} d\lambda = 0$. With above results, this equation can be written as

$$
\underbrace{\int_0^{\frac{\mathcal{L}}{\bar{p}_1}\frac{1}{1+r+\sigma v^*}} \frac{\bar{p}_1}{p_0}(1+r+\sigma v^*) - \frac{1}{p_0(1-\lambda)} \times \Big(1 - \frac{\lambda}{\mathcal{L}}\bar{p}_1(1+r+\sigma v^*)\Big) d\lambda}_{\text{net payoff when the fund is liquid}} + \underbrace{\int_{\frac{\mathcal{L}}{\bar{p}_1}\frac{1}{1+r+\sigma v^*}}^1 \frac{\mathcal{L}}{p_0 \lambda} d\lambda}_{\text{net payoff when the fund is illiquid}} = 0.
$$

Rearranging above equation gives

$$
\frac{\mathcal{L}\Big(\mathcal{L} + \mathcal{L}\log\Big(\frac{\bar{p}_1(1+r+\sigma v^*)}{\mathcal{L}}\Big) - 1\Big) - \log(1 - \frac{\mathcal{L}}{\bar{p}_1(1+r+\sigma v^*)})\Big(\bar{p}_1(1+r+\sigma s) - \mathcal{L}\Big)}{\mathcal{L} p_0} = 0
$$

Denote $X = \frac{1}{\bar{p}_1(1+r+\sigma v^*)}$, then the above condition can be written as

$$\mathcal{L}\left(\mathcal{L} + \mathcal{L}\log\left(\frac{1}{X\mathcal{L}}\right) - 1\right) - \left(\frac{1}{X} - \mathcal{L}\right)\log(1 - \mathcal{L}X) = 0. \tag{A.1}$$

Note that the solution for X in above equation is is a function of $\mathcal{L}$only. We denote $X = g(\mathcal{L})$. Rearrange above equation gives the expression (6).

Next, we summarize the properties of $g(\mathcal{L})$:

Lemma 2. *Function $g(\mathcal{L})$ has the following properties: 1) $\frac{\partial g(\mathcal{L})}{\partial \mathcal{L}} < 0$; 2) $g(\mathcal{L})$ has a lower bound as 1; 3)* $\lim_{\mathcal{L}\to 1} g(\mathcal{L}) = 1$.

To prove above lemma, we first layout some useful inequalities (Topsok, 2006):

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

$$log(1+z) \leq \frac{z}{2}\cdot\frac{6+z}{3+2z} \quad \text{for } z \geq 0.$$

We first show that there exist an solution to equation (A.1). It is clear that we have a condition that $\mathcal{L}X = \mathcal{L}g(\mathcal{L}) < 1$ such that $g(\mathcal{L}) < \frac{1}{\mathcal{L}}$. We define h function as below:

$$h_{\mathcal{L}}(X) = \mathcal{L}\left(\mathcal{L} - 1 + \mathcal{L}\log\left(\frac{1}{X\mathcal{L}}\right)\right) - \left(\frac{1}{X} - \mathcal{L}\right)\log(1 - \mathcal{L}X)$$

For each $\mathcal{L} \in [0, 1]$, we can show that

$$\lim_{X\to 1} h_{\mathcal{L}}(X) = \mathcal{L}\Big(\mathcal{L} - 1 - \mathcal{L}\log(\mathcal{L})\Big) - (1 - \mathcal{L})\log(1 - \mathcal{L}) > 0$$

$$\lim_{X\to\infty} h_{\mathcal{L}}(X) = \mathcal{L}\Big(\mathcal{L} - 1 - \mathcal{L}\log(X\mathcal{L}) + \log(1 - \mathcal{L}X)\Big) < \mathcal{L}\Big(\mathcal{L} - 1 - \mathcal{L}\log(\mathcal{L}) + \log(1 - \mathcal{L})\Big) < 0$$

So for each $\mathcal{L}$, there exists at least one solution $X = g(\mathcal{L}) \in (1, \infty)$ such that $h_{\mathcal{L}}(X) = 0$.

Then, we take implicit derivative of function $X = g(\mathcal{L})$:

$$\frac{\partial g(\mathcal{L})}{\partial \mathcal{L}} = \frac{g(\mathcal{L})^2\left(-\mathcal{L} - \log(1 - \mathcal{L}g(\mathcal{L})) - 2\mathcal{L}\log\left(\frac{1}{\mathcal{L}g(\mathcal{L})}\right)\right)}{\mathcal{L}g(\mathcal{L})(-\mathcal{L}+1) + \log\Big(1 - \mathcal{L}g(\mathcal{L})\Big)}$$

The denominator of above derivative is negative since

$$\begin{aligned}
& \mathcal{L}g(\mathcal{L})(-\mathcal{L}+1)+\log\Big(1-\mathcal{L}g(\mathcal{L})\Big) \\
\leq\quad & \mathcal{L}g(\mathcal{L})(-\mathcal{L}+1)+(-\mathcal{L}g(\mathcal{L})) = -\mathcal{L}^2 g(\mathcal{L}) < 0
\end{aligned}$$

For the numerator of $\frac{\partial g(\mathcal{L})}{\partial \mathcal{L}}$, we have

$$\begin{aligned}
& -\mathcal{L}-\log(1-\mathcal{L}g(\mathcal{L}))+2\mathcal{L}\log\Big(\mathcal{L}g(\mathcal{L})\Big) \\
& = -2+\mathcal{L}+\Big(1-\frac{2}{X\mathcal{L}}\Big)\log(1-X\mathcal{L}) \qquad\qquad (\text{from } h_{\mathcal{L}}(X)=0) \\
& \geq -2+\mathcal{L}+\Big(1-\frac{2}{X\mathcal{L}}\Big)\frac{2X\mathcal{L}}{2-X\mathcal{L}} = \mathcal{L} \geq 0
\end{aligned}$$

Therefore, we have $\frac{\partial g(\mathcal{L})}{\partial \mathcal{L}} < 0$. Combining the existence of solution $g(\mathcal{L})$ in interval $(1,\infty)$, we can conclude that for each $\mathcal{L}$, there exists only one solution $g(\mathcal{L}) \in (1,\infty)$ such that $h_{\mathcal{L}}(g(\mathcal{L})) = 0$.

Lastly, we show $\lim_{\mathcal{L}\to 1} g(\mathcal{L}) = 1$. Suppose $X = g(\mathcal{L})$ converges some constant $\hat{g}$ as $\mathcal{L} \to 1$

$$\lim_{\mathcal{L}\to 1} h_{\mathcal{L}}(X) = 1+\log\left(\frac{1}{\hat{g}}\right)-1-\left(\frac{1}{\hat{g}}-1\right)\log(1-\hat{g}) = 0.$$

As $\log(1-\hat{g}) = -\sum_{n=1}^{\infty}\frac{\hat{g}^n}{n}$, we can rewrite the above equation as

$$\log\left(\frac{1}{\hat{g}}\right)+\left(\frac{1}{\hat{g}}-1\right)\sum_{n=1}^{\infty}\frac{\hat{g}^n}{n} = \log\left(\frac{1}{\hat{g}}\right)+(1-\hat{g})\sum_{n=1}^{\infty}\frac{\hat{g}^{n-1}}{n} = 0$$

If $\hat{g} < 1$, both terms are positive; if $\hat{g} > 1$, both terms are negative. Therefore, $\lim_{\mathcal{L}\to 1} g(\mathcal{L}) = \hat{g} = 1$.

□

A.3 Corollary 1

Proof. To start, we first lay out two results from Jensen's inequality:

$$\frac{1}{\bar{p}_1^2}\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big] > 1,$$
$$(1+r)\bar{p}_1 > 1.$$

Proof for a The partial derivative of v^* on r is

$$\frac{\partial v^*}{\partial r} = \frac{1}{\sigma}\left(\frac{1}{g(\mathcal{L})}\frac{1}{\bar{p}_1^2}\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big] - 1\right).$$

When $\mathcal{L} \to 1$, so does $g(\mathcal{L}) \to 1$. Then, we have $\frac{\partial v^*}{\partial r} < 0$, and

$$\frac{\partial \mathbb{P}(v > v^*)}{\partial(-r)} = -f(v^*)\frac{\partial v^*}{\partial r} > 0.$$

That is, fund fragility is higher in the low-interest-rate regime.

Proof for b The partial derivative of v^* on σ is

$$\begin{aligned}\frac{\partial v^*}{\partial \sigma} &= -\frac{1}{\sigma^2}\Big(\frac{1}{\bar{p}_1 g(\mathcal{L})} - (1+r) - \frac{1}{g(\mathcal{L})}\frac{1}{\bar{p}_1^2}\mathbb{E}\Big[\frac{\sigma\tilde{v}}{(1+r+\sigma\tilde{v})^2}\Big]\Big) \\ &= -\frac{1}{\sigma^2 g(\mathcal{L})\bar{p}_1}\Big(1 - (1+r)g(\mathcal{L})\bar{p}_1 - \frac{1}{\bar{p}_1}\mathbb{E}\Big[\frac{\sigma\tilde{v}}{(1+r+\sigma\tilde{v})^2}\Big]\Big) \\ &= \frac{1}{\sigma^2 g(\mathcal{L})\bar{p}_1^2}\Big((1+r)g(\mathcal{L})\bar{p}_1^2 - (1+r)\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big]\Big) \\ &= \frac{1+r}{\sigma^2}\Big(1 - \frac{1}{g(\mathcal{L})}\frac{1}{\bar{p}_1^2}\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big]\Big).\end{aligned}$$

As $\mathcal{L} \to 1$, $g(\mathcal{L}) \to 1$. Then, we have

$$\frac{\partial \mathbb{P}(v > v^*)}{\partial \sigma} = -f(v^*)\frac{\partial v^*}{\partial \sigma} > 0.$$

That is, fund fragility is higher in the high monetary policy uncertainty regime.

Moreover, there is a threshold $\tilde{\mathcal{L}}$ such that when $\mathcal{L} > \tilde{\mathcal{L}}$, $\frac{\partial \mathbb{P}(v>v^*)}{\partial(-r)} > 0$ and $\frac{\partial \mathbb{P}(v>v^*)}{\partial \sigma} > 0$. The $\tilde{\mathcal{L}} \in (0,1)$ is solution of the following equation:

$$g(\tilde{\mathcal{L}}) = \frac{1}{\bar{p}_1^2}\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big].$$

Proof for c The cross partial derivative of v^* on r and σ is

$$
\begin{aligned}
\frac{\partial^2 v^*}{\partial r \partial \sigma} =& \frac{1}{\sigma^2}\left(1 - \frac{1}{g(\mathcal{L})}\frac{1}{\bar{p}_1^2}\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big]\right) \\
&+ \frac{2}{\sigma g(\mathcal{L})\bar{p}_1^3}\left(\mathbb{E}\Big[\frac{v}{(1+r+\sigma\tilde{v})^2}\Big]\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big] - \mathbb{E}\Big[\frac{v}{(1+r+\sigma\tilde{v})^3}\Big]\bar{p}_1\right) \\
=& \frac{1}{\sigma^2 g(\mathcal{L})\bar{p}_1^3}\left(g(\mathcal{L})\bar{p}_1^3 - \mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big]\bar{p}_1 + 2\sigma\left(\mathbb{E}\Big[\frac{v}{(1+r+\sigma\tilde{v})^2}\Big]\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big] - \mathbb{E}\Big[\frac{v}{(1+r+\sigma\tilde{v})^3}\Big]\bar{p}_1\right)\right).
\end{aligned}
$$

Denote $Z = \frac{1}{1+r+\sigma\tilde{v}}$, we can derive

$$
\begin{aligned}
&\mathbb{E}\Big[\frac{v}{(1+r+\sigma\tilde{v})^2}\Big]\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big] - \mathbb{E}\Big[\frac{v}{(1+r+\sigma\tilde{v})^3}\Big]\bar{p}_1 \\
=& Cov\Big(\frac{v}{(1+r+\sigma\tilde{v})^3}, \frac{1}{(1+r+\sigma\tilde{v})}\Big) - Cov\Big(\frac{v}{(1+r+\sigma\tilde{v})^2}, \frac{1}{(1+r+\sigma\tilde{v})^2}\Big) \\
=& Cov\Big(\frac{1}{\sigma}\Big(\frac{1}{Z} - (1+r)\Big) \times Z^3, Z\Big) - Cov\Big(\frac{1}{\sigma}\Big(\frac{1}{Z} - (1+r)\Big) \times Z^2, Z^2\Big) \\
=& \frac{1+r}{\sigma}\Big(Cov(Z^2, Z^2) - Cov(Z^3, Z)\Big) \\
=& \frac{1+r}{\sigma}\Big(\mathbb{E}[Z^3]\mathbb{E}[Z] - \mathbb{E}[Z^2]\mathbb{E}[Z^2]\Big).
\end{aligned}
$$

Hence,

$$
\begin{aligned}
\frac{\partial^2 v^*}{\partial r \partial \sigma} =& \frac{1}{\sigma^2 g(\mathcal{L})\bar{p}_1^4}\left(g(\mathcal{L})\bar{p}_1^4 - \mathbb{E}[Z^2]\bar{p}_1^2 + 2(1+r)\bar{p}_1\Big(\mathbb{E}[Z^3]\mathbb{E}[Z] - \mathbb{E}[Z^2]\mathbb{E}[Z^2]\Big)\right) \\
\geq& \frac{1}{\sigma^2 g(\mathcal{L})\bar{p}_1^4}\left(\bar{p}_1^4 - \mathbb{E}[Z^2]\bar{p}_1^2 + 2\Big(\mathbb{E}[Z^3]\mathbb{E}[Z] - \mathbb{E}[Z^2]\mathbb{E}[Z^2]\Big)\right) > 0.
\end{aligned}
$$

The derivation of last inequality is in Mathmatica code online. Then we have

$$
\frac{\partial^2 \mathbb{P}(v > v^*)}{\partial(-r)\partial\sigma} = \underbrace{\frac{\partial f(v^*)}{\partial v^*}}_{=0}\underbrace{\frac{\partial v^*}{\partial \sigma}\frac{\partial v^*}{\partial r}}_{<0} + f(v^*)\underbrace{\frac{\partial^2 v^*}{\partial r \partial \sigma}}_{>0} > 0.
$$

Proof for d The cross partial derivative of v^* on r and $\mathcal{L}$ is

$$\frac{\partial^2 v^*}{\partial r \partial \mathcal{L}} = \frac{1}{\sigma}\frac{1}{g^2(\mathcal{L})}\frac{1}{\bar{p}_1^2}\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big]\Big(-\frac{\partial g(\mathcal{L})}{\partial \mathcal{L}}\Big) > 0.$$

Then we have

$$\frac{\partial^2 \mathbb{P}(v > v^*)}{\partial(-r)\partial(-\mathcal{L})} = -\underbrace{\frac{\partial f(v^*)}{\partial v^*}}_{=0}\underbrace{\frac{\partial v^*}{\partial \mathcal{L}}}_{>0}\frac{\partial v^*}{\partial r} - \underbrace{f(v^*)\frac{\partial^2 v^*}{\partial r \partial \mathcal{L}}}_{>0} < 0.$$

Similarly, the cross partial derivative of v^* on σ and $\mathcal{L}$ is

$$\frac{\partial^2 v^*}{\partial \sigma \partial \mathcal{L}} = \frac{1+r}{\sigma^2}\frac{1}{g^2(\mathcal{L})}\frac{1}{\bar{p}_1^2}\mathbb{E}\Big[\frac{1}{(1+r+\sigma\tilde{v})^2}\Big]\frac{\partial g(\mathcal{L})}{\partial \mathcal{L}} < 0.$$

Then we have

$$\frac{\partial^2 \mathbb{P}(v > v^*)}{\partial\sigma\partial(-\mathcal{L})} = \underbrace{\frac{\partial f(v^*)}{\partial v^*}}_{=0}\underbrace{\frac{\partial v^*}{\partial \mathcal{L}}}_{>0}\frac{\partial v^*}{\partial \sigma} + \underbrace{f(v^*)\frac{\partial^2 v^*}{\partial \sigma \partial \mathcal{L}}}_{<0} < 0.$$

□

Monetary Policy and Fragility in Corporate Bond Funds

Internet Appendix

A Additional Evidence

	Dependent variable: $OutFlow_{i,d}$(%)	
	Full sample	Sample removing 5 days before FOMC meetings
	(1)	(2)
ΔFF_d	−0.030	−0.022
	(−0.411)	(−0.301)
Fund FE	Y	Y
Observations	3,602,106	3,034,260
Adjusted R^2	0.041	0.041

Table A.1: Daily analysis of the relationship between fund flows and Fed funds rate changes. This table reports tests for the relationship between monetary policy changes and fund flows of corporate bond mutual funds from January 2009 to December 2017. Two samples are considered, full sample and the sub-sample removing 5-days before each FOMC meeting. $OutFlow_{i,d}$ is the daily fund outflow for fund share i at day d. ΔFF_d is the daily change in the effective Fed funds rate at day d. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and date levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	Dependent variable: $OutFlow_{i,t}(\%)$					
	Full Sample			Months with FOMC meetings		
$\mathbb{1}(Illiq_{i,t})$	High^T VIX	High^T TED	High^T DFL	High^T VIX	High^T TED	High^T DFL
	(1)	(2)	(3)	(4)	(5)	(6)
ΔTFF$_t \times \mathbb{1}$(Hign^T MPU$_t^{HRS}$) $\times \mathbb{1}(Illiq_{i,t})$	-3.575^{*}	-6.485^{*}	-0.680	-5.718^{**}	-8.470^{**}	-2.860^{**}
	(-1.911)	(-1.655)	(-0.616)	(-2.187)	(-2.422)	(-2.182)
ΔTFF$_t \times \mathbb{1}$(Hign^T MPU$_t^{HRS}$)	2.562^{*}	7.023^{*}		4.875^{**}	8.689^{***}	1.311
	(1.673)	(1.891)		(2.229)	(2.931)	(0.755)
ΔTFF$_t \times \mathbb{1}(Illiq_{i,t})$	2.178	3.841	-1.420	4.629^{*}	5.832^{*}	
	(1.387)	(1.062)	(-0.911)	(1.867)	(1.870)	
ΔTFF$_t$	-0.326	-3.351	3.050^{***}	-2.845	-5.049^{**}	2.358^{**}
	(-0.255)	(-0.970)	(2.721)	(-1.384)	(-2.034)	(2.006)
Controls$_t^M \times \mathbb{1}$(Hign^T MPU$_t^{HRS}$) $\times \mathbb{1}(Illiq_{i,t})$	Y	Y	Y	Y	Y	Y
Controls$_{i,t}^F \times \mathbb{1}$(Hign^T MPU$_t^{HRS}$) $\times \mathbb{1}(Illiq_{i,t})$	Y	Y	Y	Y	Y	Y
Controls$_t^I \times \mathbb{1}$(Hign^T MPU$_t^{HRS}$) $\times \mathbb{1}(Illiq_{i,t})$	Y	Y	Y	Y	Y	Y
Fund FE $\times \mathbb{1}$(Hign^T MPU$_t^{HRS}$) $\times \mathbb{1}(Illiq_{i,t})$	Y	Y	Y	Y	Y	Y
Observations	195,955	203,293	156,563	140,426	145,865	107,692
Adjusted R^2	0.146	0.127	0.168	0.146	0.131	0.165

Table A.2: The effect of market illiquidity on monetary-policy-uncertainty-enhanced fragility (Hypothesis 5). This table reports tests for the effect of market illiquidity on monetary-policy-uncertainty-enhanced fragility for corporate bond mutual funds from January 1992 to December 2017. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. TFF$_t$, MPU$_t^{HRS}$, VIX$_t$, TED$_t$ and DFL$_t$ are monthly TFF rate in percentage point, monthly monetary policy index developed by Husted, Rogers, and Sun (2019), monthly VIX index, TED spread, and bond market illiquidity index developed by Dick-Nielsen, Feldhütter, and Lando (2012), respectively. High^T equals 1 if the corresponding variable is above the top tercile, and 0 if it is below the bottom tercile over the sample period; the opposite for High^T. Controls$_t^M$ are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicator includes $\mathbb{1}$(Low^M TFF$_t$). Controls$_{i,t}^F$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	Dependent variable: $OutFlow_{i,t}$(%)					
	Full sample			Months with FOMC meetings		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔTFF$_t$	0.980	0.946***	0.757**	0.954	1.045***	0.849**
	(1.513)	(3.193)	(2.040)	(1.434)	(3.114)	(2.050)
ΔYield slope$_t$		−0.372	−0.341		−0.680*	−0.732*
		(−1.209)	(−0.903)		(−1.839)	(−1.673)
ΔDefault spread$_t$		1.642***	2.501***		2.290***	2.984***
		(2.966)	(4.222)		(3.518)	(4.091)
ΔVIX$_t$		0.762	0.738		0.846	0.909
		(1.521)	(1.215)		(1.453)	(1.285)
$\mathbb{1}$(High^M VIX$_t$)		−1.188***	−1.230***		−1.043***	−1.019***
		(−7.446)	(−6.411)		(−5.731)	(−4.547)
$\mathbb{1}$(High^M MPU$_t^{HRS}$)		−0.239*	−0.314**		−0.154	−0.236
		(−1.730)	(−2.001)		(−0.939)	(−1.243)
Perf$_{i,t-1}$		−177.726***	−157.163***		−182.302***	−160.859***
		(−9.067)	(−7.569)		(−7.754)	(−6.372)
$R_{i,t-1}$		−21.975***	−23.133***		−18.332***	−19.634***
		(−5.185)	(−5.259)		(−3.466)	(−3.532)
Log(TNA$_{i,t}$)		0.105***	0.138**		0.103***	0.144*
		(5.823)	(2.038)		(5.029)	(1.909)
Expense$_{i,t}$		7.136	−31.998		−0.661	−39.122
		(0.603)	(−0.805)		(−0.049)	(−0.911)
Constant		−0.313*			−0.362*	
		(−1.872)			(−1.893)	
Fund FE	Y	N	Y	Y	N	Y
Observations	249,762	217,393	217,393	178,093	154,252	154,252
Adjusted R^2	0.062	0.020	0.080	0.063	0.021	0.082

Table A.3: Monetary-policy-induced fragility before 2008 (Hypothesis 1). This table reports tests for the effect of monetary policy changes on fund flows of corporate bond mutual funds from January 1992 to December 2008. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. ΔTFF$_t$ is the change in the TFF rate in percentage point. Macro controls include the change in the yield slope, the default spread, and the VIX index. $\mathbb{1}$(High^M VIX$_t$) ($\mathbb{1}$(High^M MPU$_t^{HRS}$)) equals 1 if the VIX index (the MPU^{HRS} index) is above the sample average, and 0 others. Fund characteristics include past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	Dependent variable: $OutFlow_{i,t}$(%)			
	Sample with Low^M VIX		Months with FOMC meetings & Low^M VIX	
	(1)	(2)	(3)	(4)
$\Delta\text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	4.237**	2.287	6.649***	4.777**
	(2.299)	(1.412)	(2.931)	(2.455)
ΔTFF_t	0.210	0.183	0.190	0.199
	(0.157)	(0.174)	(0.144)	(0.228)
$\text{Controls}_t^M \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	N	Y	N	Y
$\text{Controls}_{i,t}^F \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	N	Y	N	Y
$\text{Controls}_t^I \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	N	Y	N	Y
Fund FE $\times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	Y	Y	Y	Y
Observations	59,970	52,567	41,616	36,234
Adjusted R^2	0.207	0.170	0.221	0.186

Table A.4: Monetary-policy-looseness-enhanced fragility before 2008 (Hypothesis 2). This table reports tests for monetary-policy-looseness-enhanced fragility in a liquid market for corporate bond mutual funds from January 1992 to December 2008. The market is liquid if the VIX index is below the sample average. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. ΔTFF_t is the change in the TFF rate. $\mathbb{1}(\text{Low}^T\ \text{TFF}_t)$ equals 1 if the TFF rate is below the bottom tercile, and 0 if above the top tercile over the sample period. Controls_t^M are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicator includes $\mathbb{1}(\text{High}^M\ \text{MPU}_t^{HRS})$. $\text{Controls}_{i,t}^F$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

	Dependent variable: $OutFlow_{i,t}$(%)			
	Full Sample		Months with FOMC meetings	
	(1)	(2)	(3)	(4)
$\Delta\text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	8.261***	4.991*	14.252***	10.916***
	(2.599)	(1.808)	(2.946)	(2.696)
$\Delta\text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t)$	−10.301***	−7.557**	−16.391***	−12.223***
	(−3.902)	(−2.316)	(−3.658)	(−2.867)
$\Delta\text{TFF}_t \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	−8.689***	−5.881**	−14.617***	−13.560***
	(−3.493)	(−2.406)	(−3.336)	(−3.615)
ΔTFF_t	10.805***	7.963**	16.768***	13.966***
	(4.534)	(2.529)	(3.869)	(3.419)
$\text{Controls}_t^M \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	N	Y	N	Y
$\text{Controls}_{i,t}^F \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	N	Y	N	Y
$\text{Controls}_t^I \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	N	Y	N	Y
Fund FE $\times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(\text{High}^T\ \text{MPU}_t^{HRS})$	Y	Y	Y	Y
Observations	101,868	87,783	75,879	65,051
Adjusted R^2	0.151	0.144	0.164	0.159

Table A.5: Complementary effects of monetary-policy-looseness-enhanced and uncertainty-enhanced fragility before 2008 (Hypothesis 4,5). This table reports tests for complementary effect of monetary-policy-looseness and uncertainty on fragility for corporate bond mutual funds from January 1992 to December 2008. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. TFF_t is the monthly TFF rate in percentage point and MPU_t^{HRS} is monthly monetary policy uncertainty index developed by Husted, Rogers, and Sun (2019). Low^T equals 1 if the corresponding variable is below the bottom tercile, and 0 if it is above the top tercile over the sample period; the opposite for High^T. Controls_t^M are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicator includes $\mathbb{1}(\text{High}^M\ \text{VIX}_t)$. $\text{Controls}_{i,t}^F$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

$\mathbb{1}(Illiq_{i,t})$	Dependent variable: $OutFlow_{i,t}$(%)			
	Full Sample		Months with FOMC meetings	
	High^T VIX	High^M TED	High^T VIX	High^M TED
	(1)	(2)	(3)	(4)
ΔTFF$_t$ $\times$ $\mathbb{1}$(Low^T TFF$_t$) $\times$ $\mathbb{1}(Illiq_t)$	-8.897^{***}	-3.996^{**}	-17.159^{***}	-2.895^{*}
	(−4.651)	(−2.537)	(−6.216)	(−1.682)
ΔTFF$_t$ $\times$ $\mathbb{1}$(Low^T TFF$_t$)	6.956^{***}	2.328^{*}	15.131^{***}	2.109
	(4.904)	(1.908)	(6.591)	(1.532)
ΔTFF$_t$ $\times$ $\mathbb{1}(Illiq_t)$	5.088^{***}	2.572^{*}	5.740^{***}	1.846
	(3.727)	(1.950)	(3.312)	(1.386)
ΔTFF$_t$	-2.761^{***}	−0.112	-3.561^{***}	−0.034
	(−4.237)	(−0.123)	(−3.379)	(−0.040)
Controls^M_t $\times$ $\mathbb{1}$(Hign^T MPU$^{HRS}_t$) $\times$ $\mathbb{1}(Illiq_{i,t})$	Y	Y	Y	Y
Controls$^F_{i,t}$ $\times$ $\mathbb{1}$(Hign^T MPU$^{HRS}_t$) $\times$ $\mathbb{1}(Illiq_{i,t})$	Y	Y	Y	Y
Controls^I_t $\times$ $\mathbb{1}$(Hign^T MPU$^{HRS}_t$) $\times$ $\mathbb{1}(Illiq_{i,t})$	Y	Y	Y	Y
Fund FE $\times\mathbb{1}$(Hign^T MPU$^{HRS}_t$) $\times$ $\mathbb{1}(Illiq_{i,t})$	Y	Y	Y	Y
Observations	85,773	131,930	64,711	94,579
Adjusted R^2	0.166	0.140	0.170	0.151

Table A.6: The effect of market illiquidity on monetary-policy-looseness-enhanced fragility before 2008 (Hypothesis 5). This table reports tests for the effect of market illiquidity on monetary-policy-uncertainty-enhanced fragility for corporate bond mutual funds from January 1992 to December 2008. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. TFF$_t$, MPU$^{HRS}_t$, VIX$_t$, TED$_t$ and DFL$_t$ are monthly TFF rate in percentage point, monthly monetary policy index developed by Husted, Rogers, and Sun (2019), monthly VIX index, TED spread, and bond market illiquidity index developed by Dick-Nielsen, Feldhütter, and Lando (2012), respectively. High^T equals 1 if the corresponding variable is above the top tercile, and 0 if it is below the bottom tercile over the sample period; the opposite for Low^T. Controls^M_t are macro controls, including the change in the yield slope, the default spread, and the VIX index. Market indicator includes $\mathbb{1}$(Low^M TFF$_t$). Controls$^F_{i,t}$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share and month levels. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.

$\mathbb{1}(Illiq_{i,t})$	Dependent variable: $OutFlow_{i,t}$ (%)			
	Months with FOMC meetings			
	Low^T Cash	Low^T CashBond	Low^T Cash	Low^T CashBond
	(1)	(2)	(3)	(4)
$\Delta\text{TFF}_t \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(Illiq_t)$	-1.614^{*}	-1.264	-1.527^{*}	-2.529^{***}
	(-1.720)	(-1.546)	(-1.790)	(-3.171)
$\Delta\text{TFF}_t \times \mathbb{1}(Illiq_t)$	1.203	0.827	0.856	1.853^{**}
	(1.339)	(1.090)	(1.053)	(2.498)
$\text{Controls}^F_{i,t} \times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(Illiq_t)$	N	Y	N	Y
Fund FE $\times \mathbb{1}(\text{Low}^T\ \text{TFF}_t) \times \mathbb{1}(Illiq_t)$	Y	Y	Y	Y
Month $\times$ FundObj	Y	Y	Y	Y
Observations	48,525	48,468	42,189	42,311
Adjusted R^2	0.270	0.268	0.216	0.216

Table A.7: The effect of bond fund illiquidity on monetary-policy-looseness-enhanced and uncertainty-enhanced fragility before 2008 (Hypothesis 5). This table reports tests for the effect of fund illiquidity on monetary-policy-looseness-enhanced fragility for corporate bond mutual funds from January 1992 to December 2008. $OutFlow_{i,t}$ is the fund outflow for fund share i at month t. ΔTFF_t is the change in the TFF rate. Cash (CashBond) is cash holdings (cash and government bonds holdings) at the fund share and month levels. Low^T equals 1 if the corresponding variable is below the bottom tercile, and 0 if it is above the top tercile over the sample period; the opposite for High^T. $\text{Controls}^F_{i,t}$ are fund characteristics, including past performance (Perf), past return, the total net asset in log scale, and expense ratios. FundObj is lipper objective code. Coefficients (t-statistic) are reported in the shade (unshaded) rows. Standard errors are clustered at the fund share level. *, **, *** represent statistical significance at 10%, 5% and 1% level, respectively.