Competition, Reach for Yield, and Money Market Funds

JOB MARKET PAPER

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(*Latest version*: `http://scholar.princeton.edu/glaspada/publications`)

December 31, 2014

Abstract

Do asset managers reach for yield because of competitive pressures in a low rate environment? I propose a tournament model of money market funds (MMFs) to study this issue. I show that funds with different costs of default respond differently to changes in interest rates, and that it is important to distinguish the role of risk-free rates from that of risk premia. In an environment in which funds care about relative performance, an increase in the risk premium leads funds with lower default costs to increase risk-taking, while funds with higher default costs reduce risk-taking. Without changes in the risk premium, low risk-free rates reduce risk-taking. I show that these predictions are consistent with the risk-taking of MMFs during the 2006–2008 period: When risk premia increased, funds with low sponsor's reputation concerns increased risk-taking, while funds with high sponsor's reputation concerns decreased risk-taking. Further, I confirm the differential role of risk-free rate and risk premium to explain changes in fund portfolios.

*I am extremely grateful to Hyun Shin for his extraordinary guidance and encouragement. I am also deeply thankful to Markus Brunnermeier, Atif Mian, David Sraer, and Valentin Haddad for their invaluable comments and suggestions. Finally, I thank Saki Bigio, Gabriel Chodorow-Reich, Darrell Duffie, Maryam Farboodi, Harrison Hong, Jakub Jurek, Stephen Morris, Philipp Schnabl, Adi Sunderam, Wei Xiong, and all participants of the Civitas Foundation Finance Seminar and Finance Student Workshop at Princeton University for useful discussions and advice at various stages of this project. Any remaining errors are my own. Email: gla@princeton.edu. Web page: http://scholar.princeton.edu/glaspada/home.

Do money market funds "reach for yield" because of competitive pressures when risk-free rates decrease? Are there differences in the cross-section? What is the proper notion of competitive pressure for money market funds? To answer these questions, I propose a tournament model of money market funds and test its predictions on the period 2006–2008.

"Reach for yield" refers to the tendency to buy riskier assets in order to achieve higher returns. Recently, there has been much debate about asset managers reaching for yield in a low risk-free rate environment, especially in competitive industries. Asset managers are typically compensated with asset-based fees, and it has been widely observed that investors positively respond to fund performance. This induces asset managers to compete among each other over relative performance to attract money flows. The concern is that lower returns on safe assets might exacerbate this risk-taking incentive and lead asset managers to delve into riskier assets.[1] US prime money market funds (MMFs), in particular, are seen as a leading example of asset managers reaching for yield because of competitive forces.[2] Both regulators and academics have lately paid close attention to prime MMFs because of their crucial role in the recent financial crisis. However, although the possible "reach for yield" of MMFs is central to the agenda of regulators and academics, there is a relative lack of theoretical and empirical literature on the topic.[3]

The two economic forces at work in the MMF industry are: *fund competition* and *risk of "breaking the buck."* To capture these features, I model the industry as a static fund tournament with a continuum of risk-neutral funds that have heterogeneous costs of default. The cost of default in the model represents the cost of "breaking the buck" in the real world. The heterogeneity of default costs captures the real-world heterogeneity of reputational damages to fund sponsors in case their funds default. These damages include outflows from other funds in the same fund family and losses in the franchise value of other parts of a sponsor's business.[4] In terms of methodological contribution, to the best of my knowledge, this is the first paper that solves a tournament model with a continuum of players in a fully analytic way without first-order approximations.

First, I show that the tournament has a unique Nash equilibrium, fund risk-taking strictly decreases with the cost of default, and the equilibrium default probability is strictly positive for (almost) all funds. Funds trade off expected costs of default for the expected gains of outperforming competitors by taking on more risk. The fund with the highest default cost anticipates that, in

[1] See FSOC (2013), Office of Financial Research (2013), Bernanke (2013), Haldane (2014), and Yellen (2014). Similar concerns have been previously raised by Rajan (2006). On the other hand, by lowering interest rates the Federal Reserve tries to induce risky investment in the real economy.

[2] See Stein (2013): *"[...] A leading example here comes from the money market fund sector, where even small increases in a money fund's yield relative to its competitors can attract large inflows of new assets under management."*

[3] To the best of my knowledge, the only other papers on the "reach for yield" of MMFs are the recent works by Chodorow-Reich (2014), and Di Maggio and Kacperczyk (2014). See below for a literature review.

[4] Kacperczyk and Schnabl (2013) introduced this notion of sponsor's reputation concern for MMFs. In my empirical analysis, I use it as proxy for the fund's default cost to map the model to the data. See Section 6 for details.

equilibrium, it will have the lowest expected rank of performance and keeps its default probability equal to zero, regardless of other funds' actions. Funds with slightly lower default costs anticipate its move and keep their default probability slightly above zero to outperform it. This reasoning applies to the other funds in descending order of default costs. This means that, in equilibrium, funds with lower default costs face higher competitive pressure and therefore take on more risk. I show that the fund-specific competitive pressure is uniquely determined by the distribution of default costs in the industry and is independent of asset returns. Importantly, because of competition, the equilibrium default probability is positive for (almost) all funds, *regardless* of the scale of default costs in the industry. This result comes from the tournament nature of the game and would not hold if funds were compensated based on absolute performance.

The equilibrium default probability depends on asset returns only through a tournament version of the standard risk premium, which is exogenously given. This "tournament incentive" represents the risk-taking channel of competition. An increase in the risk premium increases the equilibrium default probability of all funds. However, its effect on observable risky investment is heterogeneous in the cross-section. Consider an increase in the riskiness of the risky asset that increases the risk premium. Funds with higher default costs face lower competitive pressure, and the increase in their default probability will be smaller. If the increase in the riskiness of the risky asset is sufficiently large, they will be forced to cut their risky investment to keep their probability of default sufficiently close to zero. Funds with lower default costs, on the other hand, face a higher competitive pressure and are more affected by the increase in the risk premium. If they face sufficiently high competition, they will increase their risky investment. This bifurcation of fund risk-taking in response to changes in the risk premium comes from the heterogeneity of competition in equilibrium.

Importantly, equilibrium default probability does not depend explicitly on the level of the risk-free rate. This is because, absent default, funds only care about relative performance, and if they default, they receive a fixed pay equal to their idiosyncratic default cost. The equilibrium risky investment, however, does depend on the level of the risk-free rate. If the return on safe assets decreases, funds are forced to cut their risky investment to keep the same probability of default. That is, holding the premium constant, a decrease in the risk-free rate decreases the risky investment of all funds. This anti-"reach for yield" effect is stronger for funds with higher default costs, which means that the cross-sectional differential in risky investment decreases with the risk-free rate.

These results show that to understand the risk-taking of MMFs, it is important to distinguish the level of the risk-free rate from the risk premium. Risk premia are key to trigger risk-taking but affect funds with low and high default costs in opposite ways. Low risk-free rates, on the other hand, increasing the buffer of safe assets necessary to maintain a given default probability, reduce risky investment. This effect of risk-free rates on risk-taking is peculiar to MMFs and comes from their distinctive feature of a stable net asset value and consequent risk of "breaking the buck."

In my empirical analysis, I show that these predictions are consistent with the risk-taking behavior of MMFs during the 2006–2008 period. To map the model to the data, I identify fund's cost of default with sponsor's cost of reputational damages.[5] First, I show that the rank of fund performance, not raw performance, determines money flows in the MMF industry, justifying the choice of a tournament model.

Second, I provide evidence that supports the predictions of the model on the level of risky investment in the time series. Figure 1 shows that in the period August 2007–August 2008, when the risk premium increased and the risk-free rate decreased, funds with higher default costs decreased their risky investment, while funds with lower default costs increased it, as predicted by the model. These qualitative observations are confirmed by results in Table 4, in which I disentangle the effect

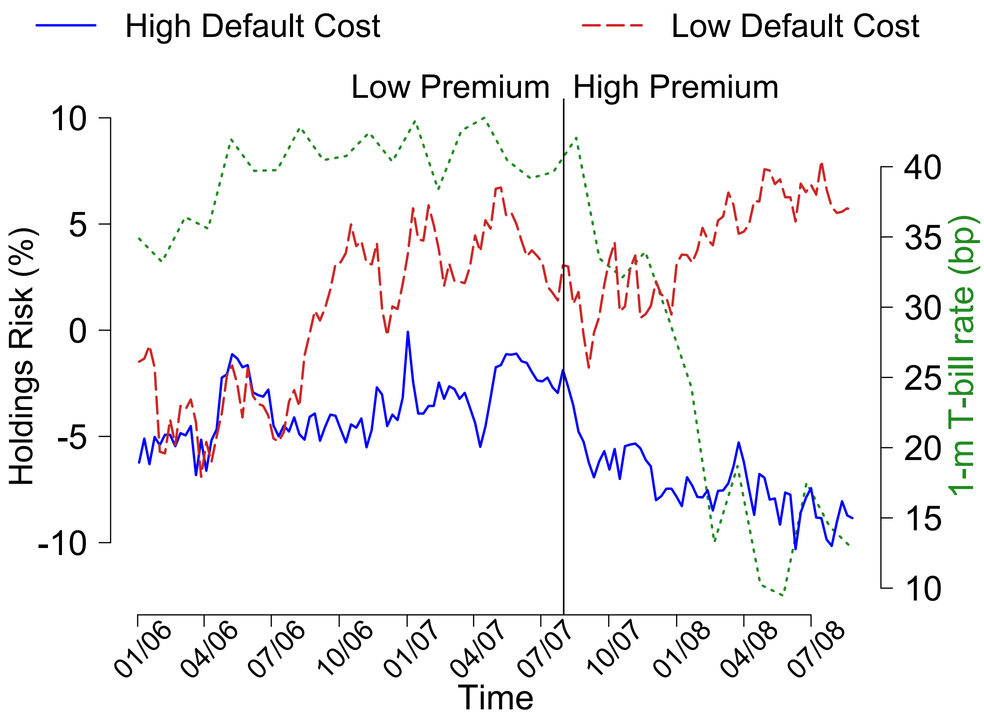


Figure 1: **MMF risk-taking in the time series: high vs low default costs.** The risk premia available to MMFs increased significantly after July 2007. The solid blue (dashed red) line is the average percentage of risky assets net of the safe assets for funds whose sponsor's reputation concern is consistently above (below) the industry median. The dotted green line is the monthly return on 1-month T-bills. See Section 6 for definitions and details.

of the risk-free rate from that of the risk premium.[6] For funds whose sponsors have reputation

[5]Following Kacperczyk and Schnabl (2013), I proxy sponsor's reputation concern with the share of non-money market fund business in the sponsor's total mutual fund business. See Section 6 for details.

[6]My main proxy for the risk premium is the excess bond premium for financial firms introduced by Gilchrist and

concerns above the industry median, an increase of 1% in the risk premium decreases the net share of risky assets by 2 percentage points, portfolio maturity by 2.1 days, and increases the share of safe assets by 1.6 percentage points. On the contrary, after an increase of 1% in the risk premium, funds whose sponsors have reputational concerns below the industry median increase the net share of risky asset by 1.5 percentage points and portfolio maturity by 1.2 days. On the other hand, a decrease of 1% in the 1-month T-bill rate increases the share of safe assets by 10.7 percentage points for funds whose sponsor's reputational concern is above the industry median, and by 8.6 percentage points for funds whose sponsor's reputational concern is below the industry median.

Finally, I fully exploit the cross-sectional variation in sponsor's reputation concerns to test model's predictions on the cross-sectional risk-taking differential and identify the effects of risk-free rates and risk premia on it. I show that funds with lower default costs always take on more risk, and confirm that the differential increases when either risk-free rates decrease or risk premia increase. In the period January 2006–July 2007, when premia were low and risk-free rates relatively high, the difference in the net share of risky assets between funds in the lowest and highest percentile of default costs was 9 percentage points. The same figure more than doubled in the period August 2007–July 2008, when premia were high and risk-free rates low. In particular, I show that changes in the risk premium are more important for the asset class composition of fund portfolios, while changes in the risk-free rate are more important for portfolio maturity. An increase of 1% in the risk premium increases the difference in risky investment between funds in the lowest and highest percentile of default costs by 6 percentage points, and the difference in the share of safe assets by 4 percentage points. A decrease of 1% in the 1-month T-bill rate increases the difference in portfolio maturity between funds in the lowest and the highest percentile of default costs by 20 days.

The reminder of the paper is organized as follows. The next section reviews the literature. Section 1 describes prime MMFs and their institutional setting. Section 2 introduces the model. Section 3 characterizes and discusses the equilibrium. Section 4 studies the response of equilibrium risk-taking to shocks in asset returns. Section 5 studies the response of equilibrium risk-taking to shocks in the competitive environment (i.e., in the distribution of default costs). Section 6 presents the empirical analysis and tests model's predictions. Section 7 concludes. Proofs of the theoretical results and supplementary material are in the appendices.

Related literature

This paper belongs to the recent and growing literature on the risk-taking and systemic importance of MMFs. The most closely related paper is Kacperczyk and Schnabl (2013); hereafter simply KS. KS empirically observe that, in the period August 2007–July 2008, funds whose sponsors have lower

Zakrajsek (2012). See Section 6 for details.

reputation concerns took on more risk than funds whose sponsors have higher reputation concerns. This paper extends their work in that: (1) I propose a theoretical model of MMFs that provides predictions on their risk-taking in both the cross-section and the time series; (2) I disentangle the effect of the risk-free rate from that of the risk premium; (3) I show that the rank of performance is the true determinant of money flows to MMFs.

To the best of my knowledge, the only other papers that study the "reach for yield" of MMFs are Chodorow-Reich (2014), and Di Maggio and Kacperczyk (2014). Chodorow-Reich (2014) considers heterogeneity in the MMF industry along the dimension of administrative costs. Di Maggio and Kacperczyk (2014) look at the cross-section of MMFs in terms of affiliation to financial conglomerates.[7] Both papers are empirical. One of the main contributions of my paper is to provide a theoretical model of MMFs to explain how competition and risk-free rates affect their risk-taking.[8]

Parlatore Siritto (2014) is the only other paper that I am aware of that presents a model of MMFs. She proposes a 3-period general equilibrium model that focuses on the effects of the new regulation put forward by the Securities and Exchange Commission (SEC), specifically the transition from a stable NAV (net asset value) to a floating NAV. This paper contributes to that debate by showing that the stable NAV, generating a risk of default and the consequent need for a buffer of safe assets, also generates a channel of monetary policy that reduces risky investment when risk-free rates decrease. Moving to a floating NAV would eliminate that channel, so that the whole industry would take on more risk in a low rate environment.

On a theoretical level, this paper belongs to the literature on fund tournaments. Most of that literature has focused on the relative risk-taking of interim winners and losers in a dynamic context (Goriaev, Palomino, and Prat, 2003; Basak and Makarov, 2012, 2014). In contrast, in this paper heterogeneity comes from the cost of default, which is an intrinsic property of the funds. Under a technical point of view, most theoretical papers on fund tournaments consider tournaments with only two players (winner and loser). Basak and Makarov (2012) consider a tournament with a continuum of funds but assume that a fund's payoff only depends on its performance relative to the average.[9] The methodological contribution of this paper is to develop a technique to solve tournaments with a continuum of players without resorting to first-order approximations.

On a broader level, this paper belongs to the literature on the transmission of monetary policy to financial intermediaries. Borio and Zhu (2012) introduced the term "risk-taking channel" of

[7]This characteristic is related to the notion of sponsor's reputation concerns that I use to map the model to the data. However, it is significantly different from the proxy I use in my empirical analysis. See Section 6 for details.

[8]Other empirical papers on MMFs are Baba, McCauley, and Ramaswami (2009), McCabe (2010), Squam Lake Group (2011), Hanson, Scharfstein, and Sunderam (2014), Chernenko and Sunderam (2014), Strahan and Tanyeri (2014), and Schmidt, Timmermann, and Wermers (2014).

[9]Basak and Makarov (2012) also assume that the flow-performance relation is convex. This paper assumes that it is linear in the rank of performance because the focus in on the competitive nature of the MMF environment alone. However, the qualitative results of my model hold for any payoff function that increases with the rank of performance.

monetary policy to denote the impact of monetary policy on the willingness of market participants to take on risk. Most of that literature has focused on banks (Adrian and Shin, 2009; Jiménez *et al.*, 2014; Landier, Sraer, and Thesmar, 2014). This paper contributes to the literature by studying how the level of risk-free rates affects the risk-taking of important non-bank financial institutions such as prime MMFs.

1 Prime Money Market Funds: Institutional Features

US prime money market funds (MMFs) are open-ended mutual funds that invest in money market instruments. Prime MMFs are pivotal players in the financial markets. As of the end of 2013, they had roughly $1.5 trillion in assets under management and held approximately 40% of the global outstanding volume of commercial papers. In particular, they are a critical source of short-term financing for financial institutions. As of May 2012, they provided roughly 35% of such funding and 73% of their assets consisted of debt instruments issued by large global banks.[10]

Similarly to other mutual funds, MMFs are paid fees as a fixed percentage of assets under management and are therefore subject to the tournament-like incentives generated by a positive flow-performance relation. On the other hand, contrary to regular mutual funds, MMFs aim to keep the net asset value (NAV) of their assets at $1 per share. They do so by valuing assets at amortized cost and providing daily dividends as securities progress toward their maturity date. Since their deposits are not insured by the government and are daily redeemable, MMFs are subject to the risk of runs. If a fund "breaks the buck," i.e. its NAV drops below $1, it will likely suffer a run, as it happened on September 16, 2008, when Reserve Primary Fund, the oldest money fund, broke the buck because its shares fell to 97 cents after writing off debt issued by Lehman Brothers.

MMFs are regulated under Rule 2a-7 of the Investment Company Act of 1940. This regulation restricts fund holdings to short-term, high-quality debt securities. For example, it limits commercial paper holdings to those that carry either the highest or second-highest rating from at least two of the nationally recognized credit rating agencies. In the period of analysis, January 2006–August 2008, MMFs were not permitted to hold more than 5% of investments in second tier (A2-P2) paper, or to hold more than a 5% exposure to any single issuer (other than the government and agencies), and the weighted average maturity of the portfolio was capped to 90 days. In 2010, after the turmoil generated by the collapse of Reserve Primary Fund, the SEC adopted amendments to Rule 2a-7, requiring funds to invest in even higher-quality assets of shorter maturities.[11]

[10] See ICI Fact Book (2013) and Hanson, Scharfstein, and Sunderam (2014).

[11] SEC Release No. IC-29132. For instance, the weighted average maturity is now capped to 60 days, funds are required to have enhanced reserves of cash and readily liquidated securities to meet redemption requests, and they can invest only 3% (down from 5%) of total assets in second tier securities.

On July 23, 2014, the SEC approved a new set of rules for MMFs.[12] The main pillar of these rules is that institutional prime MMFs will have to sell and redeem shares based on the current market-based value of the securities in their underlying portfolios. That is, they will have to move from a stable NAV to a floating NAV. The goal is to eliminate the risk of runs when the NAV falls below \$1. This new regulation, which will take effect on October 2016, has encountered the strong opposition of the industry.[13]

2 A Model of Money Market Funds

The model is a static fund tournament with a continuum of risk neutral funds of measure 1. Funds are indexed by $c \in [\underline{c}, \overline{c}] \subseteq \mathbb{R}_+$, where c represents the idiosyncratic cost of default defined below. c is distributed in the population according to a distribution function F_c, absolutely continuous on $[\underline{c}, \overline{c}]$, with density f_C.

Each fund is endowed with the same amount of initial deposits, $D > 0$. At the end of the tournament, deposits pay a gross interest rate equal to 1 to some outside investor. Funds can invest in two assets: a risk-free asset with deterministic gross return $R_f > 1$, and a risky asset with random gross return R distributed according to a distribution function F_R, absolutely continuous on $[\underline{R}, \overline{R}] \subset \mathbb{R}_+$, with density f_R.

ASSUMPTION 1. *$\underline{R} < 1$ and median$(R) > R_f$.*

As discussed below, Assumption 1 provides the proper notion of risk premium in a tournament context. Funds can neither short-sell nor borrow.

Let $x_c \in [0, D]$ be the risky investment of fund c. The *ex post* profit of fund c's portfolio is

$$\pi(x_c) = (R - R_f)x_c + (R_f - 1)D$$

Hereafter, when it causes no confusion, $\pi(x_c)$ will be simply denoted as π_c and will be referred to as fund c's *performance*. Fund c is said to default, or "*break the buck*," if $\pi_c < 0$. In that case, fund c pays a fixed cost equal to its type.

If a fund does not default, its payoff is proportional to its assets under management (AUM) at the end of the tournament. Conditional on no default, fund c's final AUM are

$$AUM(c) = (Rk(\pi_c) + a)\, D,$$

where $Rk(\pi_c)$ is the rank of fund c's performance at the end of the tournament, and a is the fraction of money flows that does not depend on relative performance. $Rk(\pi_c)$ represents a postive flow-

[12] SEC Release No. IC-31166.

[13] ICI, "A Bad Idea: Forcing Money Market Funds to Float Their NAVs" (January 2013), and http://www.preservemoneymarketfunds.org (last visited September 4, 2014).

performance relation, a can be regarded as the effect of advertising or the overall attractiveness of the industry. For simplicity a is assumed to be the same for all funds and positive.

Given a profile of *ex post* performance $\pi : [\underline{c}, \overline{c}] \to \mathbb{R}$, the rank of a performance equal to y is

$$Rk(y) := \int_{\{c\,:\,\pi_c\,<\,y\}} \mathrm{d}F_c(c) \tag{1}$$

That is, the rank of a fund's performance is equal to the measure of funds with worse performance. $Rk(\pi_c) \in [0,1]$ for all c, $Rk(\pi_c) = 1$ if c has the (strictly) highest performance, and $Rk(\pi_c) = 0$ if c has the lowest performance.[14]

The *ex post* payoff of fund c is

$$\begin{cases} \gamma\,(Rk(\pi_c) + a)\,D & \text{if } c \text{ does not default} \\ -c & \text{if } c \text{ defaults} \end{cases}$$

where $\gamma \in (0,1)$ represents the management fee paid by outside investors. The interplay between asset-based fee and positive flow-performance relation generates the fund tournament.

Under a strategy profile $x : [\underline{c}, \overline{c}] \to [0, D]$, the expected payoff of fund c is

$$\upsilon_c(x_c, x_{-c}) = \underbrace{\gamma\,D\,\mathbb{E}_R[Rk(\pi_c) + a|\pi_c \geq 0]\mathbb{P}_R(\pi_c \geq 0)}_{\text{expected tournament reward}} - \underbrace{c\,\mathbb{P}_R(\pi_c < 0)}_{\text{expected cost of default}} \tag{2}$$

where x_{-c} is the risky investment of all funds except c, and $\mathbb{E}_R[\cdot]$ and $\mathbb{P}_R(\cdot)$ are the expected value and probability measure over the risky return R, respectively.

Finally, all information above is common knowledge.

Discussion of model's assumptions

The interest rate on deposits equal to 1 represents the stable NAV of \$1 in the MMF industry. The cost of default c represents sponsor's costs when the NAV of its MMF falls below \$1. These costs include reputational costs, as well as negative spillovers to other parts of sponsor's business.

The safe asset can be regarded as a Treasury bill, while the risky asset can be regarded as a bank obligation, or some other risky fixed-income security. Under Assumption 1 negative realizations of the risky return can trigger a default if the fund is too exposed to the risky asset. The premium on the risky asset is in terms of its median because, in a tournament context, fund payoffs depend only on relative performance. The *ex post* rank of performance is equal to the *ex ante* rank of risky investment when the realized risky return is above the risk free-rate, while it is equal to the *reverse*

[14]Under this definition of performance rank, the aggregate end-of-the-game AUM coming from the tournament are equal to the initial aggregate deposits divided by 2. Since the model is static, this plays no role, and for notational simplicity I omit the normalization factor 2 in my definition.

of the *ex ante* rank of risky investment when the realized risky return is below the risk free-rate. Hence, there is a tournament-driven risk-taking incentive if and only if the realized risky return is more likely to be above the risk-free rate than below it, i.e., $median(R) > R_f$.

The assumption that a fund's payoff is proportional to its AUM is consistent with the fee structure typically used in the MMF industry (ICI Fact Book, 2013). The assumption that a fund's AUM at the end of the tournament depend on fund's net return only via the flow-performance relation is consistent with the common practice in the MMF industry of redistributing dividends to keep the NAV fixed at $1. The assumption that short-selling and borrowing are not allowed is also consistent with the regulation of MMFs.

The assumption that fund performance is a major determinant of fund flows is supported by a vast empirical literature (Chevalier and Ellison, 1997). In Section 6.2, I show empirically that the rank of performance, and not the raw performance, is the main determinant of the flow-performance relation in the MMF industry, which supports the choice of a tournament model.

Contrary to the majority of the positive theoretical literature on fund tournaments (Basak and Makarov, 2012), the above model does not assume a convex flow-performance relation. Although there is some evidence that the flow-performance relation for MMFs is convex (Christoffersen and Musto, 2002), that risk-taking channel is shut off to focus on the incentives generated only by the tournament nature of fund competition.[15] However, the qualitative predictions of the model are robust to both convex and concave specifications of the flow-performance relation.

In the above model, the flow-performance relation is exogenously given. In mapping the model to the data, this amounts to assume that investors do not take into account funds' costs of default when making their investment decisions. That is, investors do not risk-adjust funds' performance based on sponsors' reputation concerns. In Section 6.2, I show that this assumption is satisfied in the data. In Appendix A, I also present a random utility model that rationalizes this assumption and discuss possible ways to formally endogeneize a rank-based flow-performance relation.

Under specification (1) the rank of a fund's performance is equal to the measure of funds with strictly lower performance. In Appendix C, I consider the more general specification in which the rank of a fund's performance is equal to the measure of funds with strictly lower performance plus a fraction ($\delta \in [0, 1]$) of the funds with the same performance. All theoretical results in the paper are proved under the general specification, deriving conditions on δ for their validity.

The assumption that fund flows also depend on factors that are not related to funds' relative performance, e.g. advertising, has been vastly documented in the empirical literature on mutual funds (Jain and Wu, 2000). The assumption is made mainly for technical reasons as it ensures the existence of an equilibrium without imposing further conditions on the primitives of the model.

[15] Moreover, Spiegel and Zhang (2013) have recently argued that the empirically observed convexity of the flow-performance relationship in the mutual fund industry is due solely to misspecification of the empirical model.

However, the model can be solved and gives the same results even if that assumption is relaxed ($a = 0$) and substituted with a regularity condition on the distribution of default costs.

Finally, the above model abstracts away from any agency problem that may arise within the fund management company. That is, funds are identified with their sponsors.

3 The Nash Equilibrium

This section analytically characterizes the unique Nash equilibrium of the tournament. Before characterizing the equilibrium, let me introduce the following variable:

$$x_0 := \frac{R_f - 1}{R_f - \underline{R}} D \in (0, D)$$

x_0 is the maximum risky investment such that the probability of default is zero. Given a risky investment $x \in [0, D]$, the probability of default is zero for $x \leq x_0$ and strictly positive for $x > x_0$. Hereafter, I refer to x_0 as the *critical risky investment.* $D - x_0$ is the minimum buffer of safe assets required to fully insure the fund against the risk of default. Importantly, x_0 strictly increases with the risk-free rate. This means that the minimum buffer of safe assets necessary to avoid "breaking the buck" is larger when the risk-free rate is low.

As solution concept, I use the standard definition of Nash equilibrium for games with a continuum of players introduced by Aumann (1964).

Definition 1. *A risky investment strategy $x : [\underline{c}, \overline{c}] \to [0, D]$ is a Nash equilibrium of the game defined by (2) if and only if*

$$\upsilon_c(x_c, x_{-c}) \geq \upsilon_c(z, x_{-c}) \qquad \text{for all } z \in [0, D]\,,$$

almost everywhere (a.e.) on $[\underline{c}, \overline{c}]$.

Hereafter, for simplicity, I drop the "*a.e.*" notation. All following results are true *a.e.* on $[\underline{c}, \overline{c}]$.[16]

Proposition 1. *Any equilibrium risky investment $x(c)$ must be strictly decreasing, differentiable with strictly negative derivative, and $\lim_{c \to \overline{c}} x(c) = x_0$.*

The first part of Proposition 1 is the differentiability and strict monotonicity of any equilibrium. This result comes from the fact that the payoff of funds depends on the rank order of their actions.[17] The second part of Proposition 1 reveals that any equilibrium must be in the region of positive probability of default, as summarized by the following corollary.

[16] Since F_c is assumed absolutely continuous with respect to the Lebesgue measure, "*a.e.*" and "$F_c - a.e.$" coincide.

[17] Similar results are obtained in auction theory (Krishna, 2010).

Corollary 1. *In equilibrium, the probability of "breaking the buck" is strictly positive for all funds and decreasing in the cost of default.*

In the region of zero probability of default, bounded above by x_0, the expected payoff increases with the risky investment regardless of other players' actions. Hence, each fund has an incentive to invest at least x_0 in the risky asset. The fund with the highest default cost invests exactly x_0 because it anticipates that it will have the lowest rank in expectation and optimally chooses to keep its default probability equal to zero, regardless of what other funds do. The pressure of competition drives all other funds to invest more than x_0 in the attempt to outperform their competitors. The strategic interactions coming from the tournament make (almost) all MMFs not perfectly safe *ex ante*.[18] Corollary 1 can be regarded as the most basic form of risk-shifting and is the first main result on MMF risk-taking. Importantly, it holds true regardless of the scale of default costs, i.e., even if all funds have extremely large costs of default. This result would not hold if funds were compensated according their absolute performance (see Appendix B for a detailed comparison).

To explicitly determine the equilibrium, I proceed as follows. Under Assumption 1, the expected rank of a fund's performance increases with the *ex ante* rank of its risky investment. Since any equilibrium is decreasing, the rank of a fund's risky investment is equal to the mass of funds with higher cost of default. That is, given an equilibrium investment profile $x(c)$, the rank of a risky investment y is $1-F_C(x^{-1}(y))$. Since any equilibrium is differentiable with negative first derivative, I can take the first-order condition of the objective function (2) with respect to $x(c)$ and obtain an ordinary differential equation (ODE) in $\mathrm{d}x(c)/\mathrm{d}c$. The ODE, together with the boundary condition given by Proposition 1, provides a well-defined Dirichlet problem. Under regularity conditions on the primitives of the model, the Dirichlet problem can be solved exactly, and the solution is unique. Finally, I prove that the unique solution of the Dirichlet problem is indeed the unique equilibrium of the tournament by checking a second-order condition.

Proposition 2. *A Nash equilibrium exists if and only if* $\mathbb{E}_C\left[\frac{\gamma D}{\gamma D(F_C(c)+a)+c}\right] \leq \log\left(1+\frac{F_R(1)}{1-2F_R(R_f)}\right)$. *Moreover, if there is a Nash equilibrium, it must be unique.*

The equilibrium default probability is

$$p(c) = 2 \underbrace{q(R_f)}_{\substack{\textit{tournament}\\ \textit{incentive}}} \cdot \underbrace{Q(c)}_{\substack{\textit{incentive}\\ \textit{multiplier}}} ,$$

and the equilibirum risky investment is

$$x(c) = \frac{R_f - \underline{R}}{R_f - F_R^{-1}\left(p(c)\right)}\, x_0\,, \tag{3}$$

[18] Except for the fund with the highest cost of default, which has measure zero.

where

$$q(R_f) := 0.5 - F_R\,(R_f) > 0\,,$$
$$Q(\widetilde{c}) := \exp\left\{\gamma D\,\mathbb{E}_C\left[\left(\gamma D\left(F_C(c)+a\right)+c\right)^{-1}|c>\widetilde{c}\right](1-F_C(\widetilde{c}))\right\} - 1,$$

$F_R^{-1}(\cdot)$ *is the quantile function of* R*, and* $\mathbb{E}_C[\cdot]$ *is the expected value over the cost of default.*

The equilibrium default probability is uniquely determined by $q(R_f)$ and $Q(c)$. $q(R_f)$ is common to all funds, strictly positive under Assumption 1, and is referred to as the *tournament incentive*. To understand its role as risk-taking incentive, note that the *ex post* rank of fund c's performance, $Rk(\pi_c)$, depends on the *ex ante* rank of fund c's risky investment, $Rk(x_c)$, in the following way

$$Rk(\pi_c) = \begin{cases} Rk(x_c) & \text{if } R > R_f, \text{ i.e. with probability } 1 - F_R(R_f) \\ \\ 1 - Rk(x_c) & \text{if } R < R_f, \text{ i.e. with probability } F_R(R_f) \end{cases}$$

The incentive to increase the default probability by investing in the risky asset increases with the difference between the above probabilities, i.e. $2q(R_f)$. Within the debate on a competition-driven "reach for yield" of MMFs, $q(R_f)$ represents the *incentive to reach for yield*. Larger $q(R_f)$, larger the default probability and risky investment for all funds. $q(R_f)$ is the only risk-taking incentive in the model and, as discussed below, a proxy for the standard risk premium.

$Q(c)$ is fund-specific, positive, strictly decreasing in the cost of default, and goes to zero as c goes to $\bar{c}$. $Q(c)$ is referred to as the *incentive multiplier* because it determines a fund's sensitiveness to the tournament incentive by measuring the competitive pressure faced by the fund in equilibrium. To see this, let us consider the fund with the highest cost of default, $\bar{c}$. As discussed above, $\bar{c}$ anticipates that, in equilibrium, its expected performance will have the lowest rank. Hence, it decides to keep the probability of default equal to zero by investing x_0 in the risky asset, regardless of other players' actions. That is, $\bar{c}$ is not affected by fund competition, and $Q(\bar{c}) = 0$. Funds with slightly lower default costs anticipate that $\bar{c}$ will invest x_0. Hence, in order to outperform $\bar{c}$, they keep a default probability slightly greater than zero by investing a little bit more than x_0 in the risky asset. This reasoning extends to the other funds in descending order of default costs. In other words, since the fund with the highest default cost is insensitive to competition, each fund faces competitive pressure only from the funds with higher default costs. Figure 2 shows the equilibrium risky investment and the incentive multiplier as functions of the cost of default.

To gain a deeper insight into how competition works in the MMF tournament, let us take a closer look at $Q(c)$. The competitive pressure faced by an agent in a competitive context depends on: (1) *how many* competitors she has, and (2) *how competitive* her competitors can be. For a fund

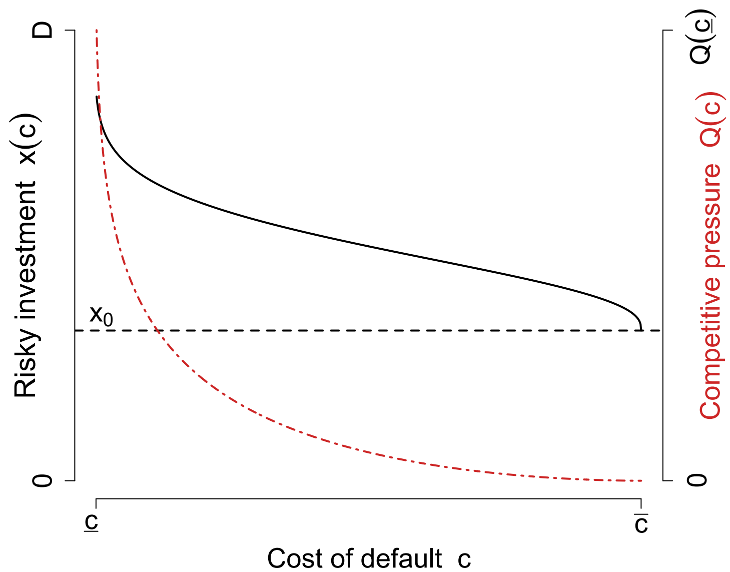


Figure 2: **Equilibrium risky investment and competitive pressure.** The solid black line (left y-axis) is the equilibrium risky investment, $x(c)$, as function of the default cost. The dashed black line is the maximum risky investment such that the probability of default is zero, x_0. The dot-dashed red line (right y-axis) is the incentive multiplier, $Q(c)$, as function of the default cost. $Q(c)$ measures the competitive pressure faced by each fund in equilibrium.

$\widetilde{c}$ in the MMF tournament, the multiplier, $Q(\widetilde{c})$, captures both effects through the interaction term:

$$\mathbb{E}_C \left[\left(\underbrace{\gamma D \left(F_C(c) + a \right) + c}_{\substack{\text{marginal cost} \\ \text{of risky investment}}} \right)^{-1} \middle| c > \widetilde{c} \right] \cdot \underbrace{\left(1 - F_C(\widetilde{c})\right)}_{\substack{\text{mass of funds with} \\ \text{higher default costs}}}$$

$1 - F_C(\widetilde{c})$ represents the mass of fund $\widetilde{c}$'s competitors, i.e. the mass of funds with higher default costs. $\mathbb{E}_C \left[\left(\gamma D \left(F_C(c) + a\right) + c\right)^{-1} | c > \widetilde{c} \right]$ captures the competitiveness of fund $\widetilde{c}$'s competitors: it is the average of their inverse marginal cost of increasing the default probability by investing in the risky asset. Investing more in the risky asset increases the *ex post* performance rank if the realized risky return is above the risk-free rate, but it *decreases* the *ex post* performance rank if the realized risky return falls below the risk-free rate. Hence, for a competitor c, increasing the probability of default by investing more in the risky asset has both a *direct cost*, its explicit cost of default c, and an *opportunity cost*, the AUM that c will receive at the end of the tournament if it does not default, and the risky return falls below the risk-free rate. This opportunity cost is $\gamma D \left(F_C(c) + a\right)$.[19] The

[19]This is because the equilibrium risky investment decreases with the cost of default. If the risky return falls below the risk-free rate, the *ex post* rank of performance is equal to the mass of funds with lower costs of default.

economic intuition is: the lower the competitors' marginal cost of risky investment is, the more competitive they can be. Figure 3 shows the two components of competitive pressure at work.

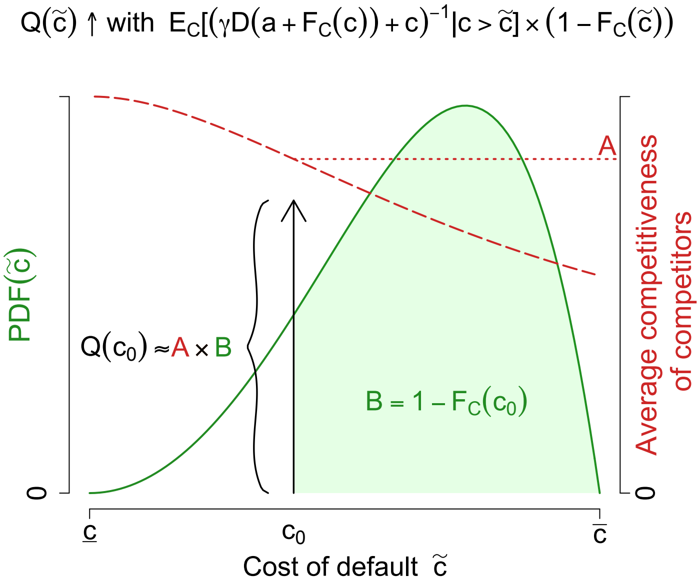


Figure 3: **Components of competitive pressure.** The solid green line (left y-axis) is the probability density function of the default cost, f_C. The green shaded area is the mass of funds with default costs higher than c_0 and represents the mass of fund c_0's competitors. The long-dashed red line (right y-axis) is the average inverse marginal cost of risky investment for funds with default costs higher than $\tilde{c}$ as a function of $\tilde{c}$ and represents the competitiveness of a fund's competitors. The upward arrow is the product of the mass of fund c_0's competitors and their competitiveness (B and A, respectively) and represents the competitive pressure faced by c_0 in equilibrium.

$Q(c)$ shows that competitive pressure (1) is a local property in the MMF tournament, in the sense that it is fund-specific, and (2) is determined only by the distribution of default costs in the industry. Importantly, competitive pressure does not depend on the distribution of returns.

Standard risk premium, approximate equilibrium, and sufficient conditions

The tournament incentive is a spread between risky and safe returns expressed in terms of probabilities. Under mild regularity conditions on the distribution of risky returns, it can be directly related to the standard risk premium.[20]

Lemma 1. *Suppose that F_R is twice differentiable at $\mu := \mathbb{E}[R]$ and $|F_R(\mu) - 0.5|$ is small. Then,*

$$q(R_f) \approx f_R(\mu)\,(\mu - R_f) \qquad \textit{for small } \mu - R_f > 0.$$

[20]Hereafter, $f \approx g(x)$ for small x means $f = g(x) + o(x)$ in the standard small $o(\cdot)$ notation.

If the distribution of risky returns is sufficiently smooth, with its mean and median being close, $q(R_f)$ is linearly proportional to the standard risk premium, $\mu - R_f$, when the standard risk premium is small. Since the spread on the risky securities available to MMFs is typically very small, the approximation provided by Lemma 1 is likely to hold in the data. This relation suggests to proxy the tournament incentive with a measure of risk premium in the empirical analysis.

For some comparative statics I study below, the equilibrium risky investment (3) is not easily tractable. However, under mild regularity conditions, it can be written in a more tractable form.

Corollary 2. *Suppose that F_R is twice differentiable on $[\underline{R}, 1]$ and $f_R(\underline{R}) > 0$. Then, for small equilibrium default probability, i.e. small $q(R_f)Q(c)$, the equilibrium risky investment is*

$$x(c) \approx \left(1 + 2\frac{q(R_f)}{f_R(\underline{R})(R_f - \underline{R})}Q(c)\right) x_0 \,. \tag{4}$$

If the distribution of risky returns is sufficiently smooth in its left tail, the equilibrium risky investment is proportional to the tournament incentive, normalized by a measure of tail risk and scaled by the fund-specific multiplier. Approximation (4) always holds for funds with higher default costs because they keep the default probability close to zero. It also holds for all funds if the maximum competitive pressure in the industry is sufficiently small. In the following, I will use (4) to study how the cross-sectional risk-taking differential reacts to changes in the risk premium and riskiness of the risky asset.

Finally, the following corollary provides two sufficient conditions, with a straightforward economic interpretation, for the existence of the equilibrium.

Corollary 3. *The equilibrium exists if*

$$\textit{either} \quad \left(e^{1/a} - 1\right)^{-1} \geq 2\frac{q(R_f)}{F_R(1)}\,; \qquad \textit{or} \quad \left(e^{\gamma D/\underline{c}} - 1\right)^{-1} \geq 2\frac{q(R_f)}{F_R(1)}$$

The first condition says that the fraction of AUM that do not depend on fund performance must be sufficiently larger than the tournament incentive, normalized by the probability of risky returns falling below the rate on deposits (\$1). The second condition says that the minimum default cost in the industry must be sufficiently larger than the normalized tournament incentive. Both conditions are likely to hold in the MMF industry, where the spread on eligible risky securities is small, and therefore $q(R_f)$ is also small (Lemma 1). Moreover, the second condition is likely to hold more generally because the cost of "breaking the buck," as it happened to Reserve Primary Fund, is arguably very high in absolute terms even for those funds with relatively low default costs.

4 Shocks to Asset Returns

This section studies how the equilibrium responds to changes in the risk-free rate and distribution of risky returns. The goal of this section is to characterize the "reach for yield" behavior of MMFs in response to changes in the available investment opportunities.

The equilibrium default probability, $p(c)$, depends on asset returns only via the tournament incentive, $q(R_f) = 0.5 - F_R(R_f)$. It does not depend on the level of the risk-free rate or other parts of the risky return distribution. This is because, absent default, the payoff only depends on relative performance, and in case of default, the payoff is a fund-specific fixed cost that is independent of how much the fund defaulted.[21]

Proposition 3. *The equilibrium default probability $p(c)$ increases with the tournament incentive $q(R_f)$ for all funds, except for that with the highest default cost for which it is always zero. The effect of $q(R_f)$ on the equilibrium default probability is stronger for funds with lower default costs.*

Proposition 3 follows immediately from the formula for the equilibrium default probability, $p(c) = 2q(R_f)Q(c)$. An increases in $q(R_f)$ increases the equilibrium default probability of all funds, except that with the highest default cost, for which $Q(\bar{c}) = 0$. Since the effect of $q(R_f)$ is weighted by the idiosyncratic multiplier $Q(c)$, it is stronger for funds with lower default costs.

The equilibrium risky investment, on the other hand, does depend on the level of the risk-free rate and the risky return distribution. The distribution of risky returns affects risky investment via $F_R^{-1}(p(c))$. Importantly, only the left tail of the distribution matters. This is because from the no-short-selling constraint $x(c) \leq D$, and hence the equilibrium default probability must be smaller than or equal to the probability that the risky return falls below 1, i.e. $p(c) \leq F_R(1)$. The risk-free rate, on the other hand, affects the equilibrium risky investment both explicitly via its level, R_f, and implicitly via the tournament incentive, $q(R_f)$. In the following section, I study the effects of these variables on fund risky investment both separately and jointly. This allows me to make predictions on the risky investment of MMFs when changes in the risk-free rate, risk premium and riskiness of the risky assets occur simultaneously and to disentangle the different channels.

4.1 Changes to the risk premium, holding the risk-free rate constant

First, I consider the effect of changes in the risk premium, holding the risk-free rate constant. In the real world, the premium on risky assets usually increases with their riskiness. To mimic this scenario, I consider an increase in the tournament incentive accompanied by an increase in the left tail of the return distribution.

I show that under realistic conditions funds with high and low default costs respond in opposite ways to such changes. The increase in the tournament incentive increases the equilibrium default probability of (almost) all funds. On the other hand, for a given default probability, a shift to the left in the return distribution reduces the corresponding amount of risky investment. The heterogeneous competitive pressure in equilibrium determines which effect dominates.

[21] This feature can be regarded as a Value-at-Risk rule, or a form of limited liability.

Let $H := \dfrac{F_R(r)}{F_R(1)}$ for all $r \in [\underline{R}, 1]$ be the left tail of F_R, renormalized to 1 so to have a proper distribution function. Suppose there is a stochastic shift from $H^{(1)}$ to $H^{(2)}$, both with support $[\underline{R}, 1]$. In particular, assume that $H^{(1)}$ dominates $H^{(2)}$ in terms of likelihood ratio order, $H^{(1)} \succ_{LRD} H^{(2)}$. Finally, suppose the tournament incentive goes from $q^{(1)}$ to $q^{(2)} > q^{(1)}$.

Proposition 4. *Let $H^{(1)} \succ_{LRD} H^{(2)}$ and $q^{(1)} < q^{(2)}$.*

(i) If $\dfrac{q^{(2)}}{q^{(1)}} > (\geq) \sup \dfrac{H^{(2)}}{H^{(1)}}$, all funds (weakly) increase their risky investment.

(ii) If $\dfrac{q^{(2)}}{q^{(1)}} < \sup \dfrac{H^{(2)}}{H^{(1)}}$,

(a) funds with relatively high costs of default decrease their risky investment;

(b) funds with relatively low costs of default increase their risky investment if and only if they face sufficiently high competitive pressure.

Moreover, if $\dfrac{H^{(2)}}{H^{(1)}}$ is decreasing, the cutting point between (a) and (b) is unique.

Part (i) provides a predictable result: if the increase in the tournament incentive is sufficiently larger than the increase in the riskiness of the risky asset,[22] all funds increase their risky investment.

Part (ii) considers the more realistic and interesting scenario when the increase in the probability of low returns and that in the tournament incentive are of comparable sizes.[23] The intuition for this case is as follows. Funds with higher default costs face lower competitive pressure and keep their default probability closer to zero. Therefore, their risky investment is more sensitive to shocks in the probability of very low returns. Under likelihood ratio dominance, the growth in the leftmost part of the left tail of the return distribution is greater than the growth in the tournament incentive. Hence, even though their default probability increases, funds with higher default costs are forced to decrease their risky investment.[24] On the other hand, funds with lower default costs have a larger incentive multiplier, due to larger competitive pressure, and are more sensitive to shocks in the tournament incentive. If competitive pressure on those funds is sufficiently high, the increase in q dominates, and their risky investment increases. In other words, the heterogeneous competitive pressure in equilibrium generates a bifurcation in the response of funds' risky investment to changes in the risk premium.

Importantly, this bifurcation occurs even if we substitute the likelihood ratio dominance in the left tail with a simple decrease in the lowest possible risky return (i.e., $\underline{R}^{(2)} < \underline{R}^{(1)}$), confirming the robustness of the above economic intuition.

[22] I.e., the growth in q is larger than the maximum growth in the left tail of the return distribution.

[23] I.e., $q^{(2)}/q^{(1)} < \sup H^{(2)}/H^{(1)}$.

[24] Except the fund with the highest cost of default, which always invests x_0. Since, by assumption, $H^{(1)}$ and $H^{(2)}$ have the same support, x_0 does not change after the stochastic shift in the tail.

These results suggest that the cross-sectional risky investment differential increases with the premium and riskiness of the risky asset. When competitive pressure on funds with lower default costs is high, this intuition is formalized by Proposition 4 (*ii*). To have a formal result for when the competitive pressure on those funds is low, I use the approximate equilibrium (4):

$$x_{app}(c) := (1 + 2\widetilde{q}Q(c))\, x_0, \qquad where \quad \widetilde{q} := \frac{q(R_f)}{f_R(\underline{R})(R_f - \underline{R})}$$

As discussed above, this approximation is valid for all funds when the competitive pressure on funds with lower default costs is low. Since $\widetilde{q}$ incorporates both the tournament incentive and the risk of low returns, I differentiate the approximate equilibrium w.r.t. $\widetilde{q}$ to capture the effect of a simultaneous change in both variables.[25]

Corollary 4. $\dfrac{\mathrm{d}}{\mathrm{d}\widetilde{q}}\left|\dfrac{\mathrm{d}x_{app}(c)}{\mathrm{d}c}\right| > 0$ *for all c.*

Corollary 4 confirms that the cross-sectional risky investment differential increases with the risk premium also when competitive pressure on funds with lower default costs is low.

4.2 Changes to the risk-free rate, holding the risk premium constant

Here I consider changes in the risk-free rate, holding the tournament incentive $q(R_f)$ constant. Since q is proportional to the standard risk premium, this amounts to assume that the risk premium remains constant when the risk-free rate changes. This exercise can be regarded as a rigid shift of the distribution of risky returns together with the risk-free rate.

Holding the tournament incentive constant, a decrease in the risk-free rate does not change the equilibrium default probability of any fund. On the other hand, it forces all funds to invest more in the safe asset to keep the same probability of default in equilibrium.

Proposition 5. *Holding the tournament incentive $q(R_f)$ constant, the equilibrium risky investment strictly increases with the risk-free rate for all funds.*

This effect on equilibrium risky investment is stronger for funds with relatively higher default costs. To see this, let us consider the following scenario. Suppose that the competitive pressure on the fund with the lowest default cost, $\underline{c}$, is sufficiently high so that its equilibrium default probability is exactly equal to $F_R(1)$. That is, $\underline{c}$ fully invests its portfolio in the risky asset, i.e., $x(\underline{c}) = D$. Holding $q(R_f)$ constant, this equilibrium investment is unaffected by changes in the level of the risk-free rate. On the other hand, in equilibrium, the fund with the highest default cost invests exactly x_0, which increases with the risk-free rate. Hence, when the risk-free rate decreases, holding $q(R_f)$ constant, the risky investment differential between funds with the highest and lowest default costs increases. This intuition is summarized by the following corollary.

[25] Note that $\mathrm{d}x_{app}/\mathrm{d}\widetilde{q} > 0$ for all c. In Proposition 4, this corresponds to (*i*) vs. (*ii*) when competitive pressure is low, which is the necessary condition for x_{app} to be a valid approximation of the equilibrium for all funds.

Corollary 5. *Holding $q(R_f)$ constant, if $\underline{R} > 2 - R_f$, the cross-sectional risky investment differential decreases with the risk-free rate. That is,*

$$\frac{\partial}{\partial R_f}\left|\frac{\mathrm{d}x(c)}{\mathrm{d}c}\right| < 0 \quad \text{for all } c \text{ if } \underline{R} > 2 - R_f.$$

The partial derivative with respect to R_f indicates that $q(R_f)$ is being held constant. The assumption that the lowest possible return on the risky asset is not too low is likely to hold in the data,[26] since MMFs can only invest in securities of the highest credit quality and very short maturity. Moreover, for the approximate equilibrium (4) of Corollary 2, the result in Corollary 5 holds true without any assumption on $\underline{R}$, further confirming the above economic intuition.

4.3 Simultaneous changes in the risk premium and risk-free rate

Finally, in the real world, periods of low risk-free rates are often associated with periods of high risk premia. Here I do comparative statics for this scenario.

For simplicity, I hold the distribution of risky returns constant, so that a decrease in the risk-free rate, R_f, mechanically increases the tournament incentive, $q(R_f) = 0.5 - F_R(R_f)$.[27] This corresponds to a mechanical increase in the risk premium (Lemma 1). In the following proposition, the symbol of total derivative with respect to R_f indicates exactly this scenario: $q(R_f)$ is allowed to vary with R_f, while the distribution of returns is held constant. That is, $\mathrm{d}x/\mathrm{d}R_f > (<) 0$ means that risky investment decreases (increases) when the risk-free rate goes down and the tournament incentive (i.e., the premium) goes up.

ASSUMPTION 2. *The reverse hazard rate of the risky return, $\frac{f_R}{F_R}$, is non-increasing on $[\underline{R}, 1)$.*

Proposition 6. *Under Assumption 2, there exists $c^* \in (\underline{c}, \overline{c})$ s.t.*

i) $\dfrac{\mathrm{d}x(c)}{\mathrm{d}R_f} > 0$ *for all $c > c^*$;*

ii) $\dfrac{\mathrm{d}x(c)}{\mathrm{d}R_f} < 0$ *for all $c < c^*$ if and only if the competitive pressure on the funds with the lowest cost of default, $Q(\underline{c})$, is sufficiently high.*

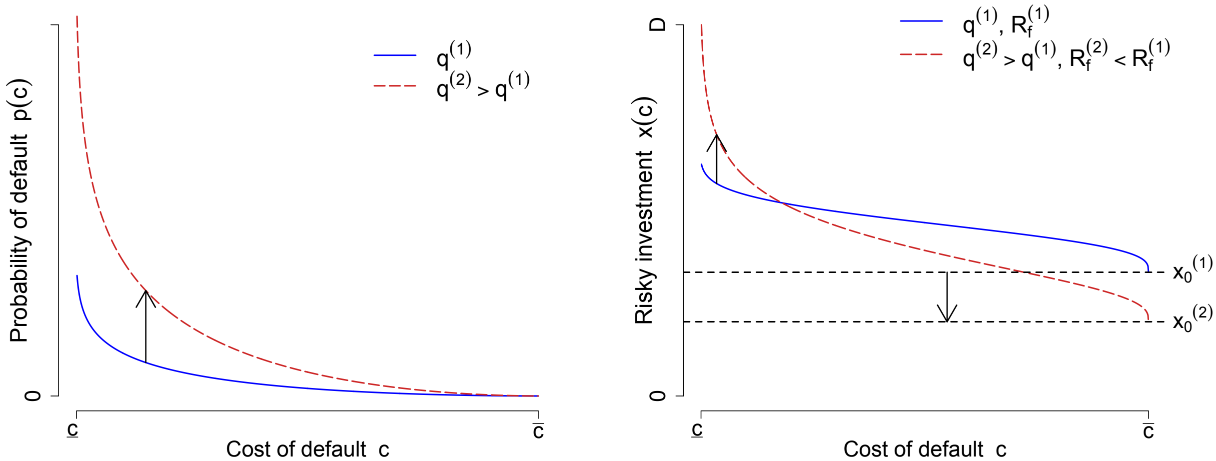
A decrease in the risk-free rate that mechanically increases the tournament incentive also increases the equilibrium default probability of (almost) all funds, with the effect being stronger for funds with lower default costs. On the other hand, holding the default probability constant, a decrease in the risk-free rate decreases the equilibrium risky investment of all funds, with the effect being stronger for funds with higher default costs. The idiosyncratic multiplier, $Q(c)$, determines which

[26] Unless the net risk-free rate is exactly zero, which is ruled out by model's assumption.

[27] For simplicity, I do not consider an increase in the left tail of the return distribution because, from the previous section, we already know that its effect goes in the same direction as that of a decrease in R_f.

effect dominates by measuring the relative importance of fund competition. To see this, take the fund with the highest cost of default, $\bar{c}$. $\bar{c}$ is unaffected by competition ($Q(\bar{c}) = 0$) and always keeps the equilibrium default probability equal to zero by investing exactly x_0. Since x_0 increases with R_f, after a decrease in the risk-free rate, $\bar{c}$ is forced to cut its risky investment to keep its default probability equal to zero, even though $q(R_f)$ increases. On the other hand, funds with relatively low costs of default face a higher competitive pressure, captured by higher $Q(c)$. If competition is sufficiently strong, $Q(c)$ is sufficiently large and the effect on the default probability via $q(R_f)$ dominates. Figure 4 qualitatively shows this result.

Finally, note that Assumption 2 is very weak. Many common distributions with support in $\mathbb{R}_+$ satisfy a decreasing reverse hazard rate condition in the left tail, including uniform, log-normal, Beta, chi-squared, and exponential (Shaked and Shanthikumar, 1994). Even more importantly, Assumption 2 is not necessary for part (i) of Proposition 6.



(a) Equilibrium default probability

(b) Equilibrium risky investment

Figure 4: **Equilibrium risk-taking when the premium (q) increases and the risk-free rate (R_f) decreases.** Left panel: default probability (unaffected by changes in R_f). Right panel: risky investment.

5 Shocks to the competitive environment

For now I have only considered how fund risk-taking responds to shocks in investment opportunities. This section studies how it responds to changes in the competitive environment. As discussed in Section 3, fund-specific competitive pressure is uniquely determined by the distribution of default costs. Suppose the distribution of default costs shifts from $F_C^{(1)}$ to $F_C^{(2)}$, both with support $[\underline{c}, \bar{c}]$.

Proposition 7. *If $F_C^{(2)} \succ_{LRD} F_C^{(1)}$, there exist $c_* \leq c^* \in (\underline{c}, \overline{c})$ s.t. equilibrium default probability and risky investment decrease for all $c < c_*$ and increase for all $c \in (c^*, \overline{c})$. The equilibrium default probability and risky investment of $\overline{c}$ remain the same: 0 and x_0, respectively.*

The intuition is as follows. The equilibrium risk-taking of fund $\widetilde{c}$ depends on the distribution of default costs only through the incentive multiplier $Q(\widetilde{c})$, which strictly increases with

$$\mathbb{E}_C\left[(\gamma D(F_C(c)+a)+c)^{-1} \,|c>\widetilde{c}\right](1-F_C(\widetilde{c})) = \int_{\widetilde{c}}^{\overline{c}} \frac{f_C(u)\mathrm{d}u}{\gamma D(F_C(u)+a)+u}. \tag{5}$$

The fund with the highest default cost, $\overline{c}$, is unaffected by shocks to the distribution of default costs because it is unaffected by competition. That is, $Q(\overline{c}) = 0$ under any F_C. For the other funds with relatively high default costs, the LRD shift increases both the mass of competitors ($f_C^{(2)}(u) > f_C^{(1)}(u)$ in the upper tail) and their competitiveness by lowering the opportunity cost of risky investment ($F_C^{(2)}(u) < F_C^{(1)}(u)$ everywhere). As a result, for large $\widetilde{c}$, the right-hand side of (5) increases, increasing the multiplier and so the risk-taking of funds with relatively high default costs. On the other hand, for the fund with the lowest default cost $\underline{c}$, the mass of competitors remains equal to 1, and their average opportunity cost of risky investment does not change.[28] However, the LRD shift decreases the average competitiveness of $\underline{c}$'s competitors by increasing the average cost of default in the industry. Hence, for $\underline{c}$ (and the other funds with relatively low default costs), a shift of F_C to the right decreases the incentive multiplier and so the risk-taking.[29]

Intuitively, if the distribution of default costs shifts to the right, competition becomes relatively stronger for funds with higher costs of default, and relatively weaker for funds with lower costs of default. Again, this result shows that, in the MMF tournament, competitive pressure is not a global property of the industry but a local property of each fund.

Proposition 7 suggests that shocks to the competitive landscape might have surprising effects in the aggregate. For example, if the right tail of the distribution of default costs is sufficiently fat, an increase in the fraction of funds with relatively high default costs could increase aggregate risk-taking rather than decrease it. This is because the increase in risk-taking by funds with higher default costs could more than offset the decrease in risk-taking by funds with lower default costs.

Model Predictions: Summary

The model makes the following testable predictions.

P.1 Funds with lower costs of default always hold more risky assets.

[28]Specifically, $\int_{\underline{c}}^{\overline{c}} \frac{f(u)\mathrm{d}u}{\gamma D(F(u)+a)} = \frac{1}{\gamma D}\log\left(1+a^{-1}\right)$ for any CDF F on $[\underline{c}, \overline{c}]$.

[29]The assumption of LRD is made only for simplicity. For Proposition 7 to hold, it is sufficient to assume a first-order stochastic dominance shift such that the two density functions cross only a finite number of times.

P.2 Holding the risk-free rate constant, an increase in the risk premium:

(a) decreases the risky investment of funds with higher default costs;

(b) increases the risky investment of funds with lower default costs (if and only if they face sufficiently high competitive pressure);

(c) always increases the cross-sectional differential.

P.3 Holding the risk premium constant, a decrease in the risk-free rate:

(a) decreases the risky investment of all funds;

(b) increases the cross-sectional differential.

P.4 When the fraction of funds with relatively high costs of default increases, funds with lower default costs decrease their risk-taking, while funds with higher default costs increase it.

The following empirical analysis provides evidence that supports predictions P.1 to P.3. Testing P.4 is left for future work.

Default Probability

The model also makes predictions on the equilibrium default probability. Specifically, all funds have a strictly positive probability of "breaking the buck," and this probability decreases with fund's cost of default. That is, all MMFs are not perfectly safe *ex ante*. Also, the probability of "breaking the buck" increases with the risk premium, with the effect being stronger for funds with lower default costs. The level of the risk-free rate, on the other hand, does not affect the probability of default.

Since in the data I do not observe MMF portfolio holdings at the security level, I cannot test these predictions in my empirical analysis. However, Brady, Anadu, and Cooper (2012) find that at least 21 MMFs would have broken the buck if they had not received sponsor support between 2007 and 2011. That period was characterized by low risk-free rates and high risk premia for MMFs. Their data suggest that sponsor support was frequent and significant: 78 MMFs (out of a total of 341 MMFs) received sponsor support in 123 instances for a total amount of at least $4.4 billion. This evidence supports model's predictions on the default probability of money market funds.

6 Empirical Analysis

As other recent studies on prime MMFs, I focus on institutional funds because they exhibit a stronger flow-performance relation than retail funds (KS; Chernenko and Sunderam, 2014). I consider the period from January 2006 to August 2008 because in this period there were significant variations in both the risk premium and the risk-free rate. I use those variations to identify the differential effects of risk premia and risk-free rates on fund risk-taking highlighted by the model.

Mapping the model to the data

To map the model to the data, I use the notion of sponsor's reputation (or business) concern introduced by KS. The fund's cost of default in the model is the sponsor's cost of possible negative spillovers in the data. The rationale is that sponsors with a larger share of non-MMF business expect to incur in larger costs if the NAV of their MMFs falls below \$1. This is because of possible outflows from other mutual funds managed by the same sponsor or a loss of sponsor's other business due to reputational damages. Following KS, I proxy sponsor's reputation concern using

$$Fund\,Business = \frac{\text{sponsor's mutual fund assets not in institutional prime MMFs}}{\text{sponsor's total mutual fund assets}}$$

Fund Business is the share of sponsor's mutual fund assets that are not in prime institutional MMFs. Another plausible measure of sponsor's reputation concern is affiliation to financial conglomerates (e.g., banks or insurance companies). However, this proxy (*Conglomerate*) is a binary variable, while in my model the cost of default is a continuous variable. *Fund Business* is continuous by construction and is therefore the natural proxy for the model's cost of default.[30]

As discussed above, the tournament incentive $q(R_f)$ in the model is mapped into the risk premium in the data. My main proxy for the risk premium is the excess bond premium for financial firms introduced by Gilchrist and Zakrajsek (2012), hereafter referred to as *GZ Premium*. Since MMFs mainly invest in debt securities issued by financial firms, this is the most appropriate measure of risk premium for MMFs. As robustness check, I also use an index of realized spreads on the risky securities available to MMFs. This index is defined and discussed below.

My main proxy for the risk-free rate is the return on 1-month T-bills. Since in the tournament model the risk-free rate affects fund risk-taking through the return on safe assets (e.g., treasuries), and MMFs are restricted to invest only in short-term securities, this is the appropriate proxy for the model's risk-free rate. As robustness check, I also use the return on 3-month T-bills as secondary proxy for the risk-free rate.

The data set

I construct a data set that maps MMFs to their sponsors. Data on individual MMFs are provided by iMoneyNet. Data on fund sponsors are from the CRSP Mutual Fund Database.

iMoneyNet data are the most comprehensive source of information on MMF holdings and have been used by KS, Chodorow-Reich (2014), and Di Maggio and Kacperczyk (2014). They are at

[30]However, in some regressions, I also use *Conglomerate* as extra control for sponsor's reputation concern.

the weekly, share-class level and contain information on yields, assets under management, expense ratio, age, portfolio composition by instrument type, and weighted average maturity. Since my model is at the fund level, I aggregate share classes by fund and compute fund characteristics as the weighted average of the share class values, with assets per share class as weights. Details on the construction of the data set are in Appendix D.

Data on the *GZ Premium* are at the monthly level from Simon Gilchrist's website: `http://people.bu.edu/sgilchri/Data/data.htm`. Data on T-bill rates are from Kenneth French's website (`http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html`) and CRSP.

Sumamry Statistics

Table D.1 in Appendix D shows summary statistics for all institutional prime MMFs as of January 2006. The sample includes 143 funds and 82 sponsors. The average fund size is \$6.3 billion and the average fund age is 11.2 years. The spread is computed as the annualized gross yield (i.e., before expenses) minus the yield of the 1-month Treasury bill. The average spread is 7.5 basis points and the average expense ratio is 35.9 basis points. In terms of assets holdings, funds hold 31.4% in commercial paper, 19.9% in floating-rate notes, 13.4% in repurchase agreements, 13.6% in asset-backed commercial paper, 12.4% in bank obligations, 5.9% in U.S. Treasuries and agency-backed debt, and 3.4% in time deposits. The average family size at the sponsor level is \$73.3 billion, and the average fund business is 74.5%.[31]

Since my analysis focuses on the different risk-taking of MMFs with high and low default costs, I check that funds whose sponsors have different levels of reputation concern do not significantly differ along other dimensions. Column (2) and (3) of Table D.1 show summary statistics for funds whose sponsors have *Fund Business* above and below the industry median, respectively. I find that both groups are quite similar in terms of observable characteristics, such as spread, expense ratio, maturity, age, and holdings. The main differences are that funds sponsored by firms with higher *Fund Business* are (1) smaller on average, and (2) on average less likely to be part of financial conglomerates. These results suggest that the extent of a sponsor's non-MMF business is not systematically correlated with other observable fund characteristics.

Appendix D also analyzes the distributional properties of *Fund Business*. It shows that there is significant, widespread variation in the cross-section of sponsors' reputation concerns, which supports the validity of a "continuum-of-funds" approach and helps the identification of reputation effects on the cross-sectional risk-taking differential. In the online appendix, I also show that *Fund Business* does not covary with fund's incurred expenses, which means that my results are not driven by the cross-sectional variation considered by Chodorow-Reich (2014). On the other hand, the cross-sectional correlation between *Fund Business* and affiliation to a financial conglomerate–

[31] These results are very close to those of KS, confirming the consistency of my data set with theirs.

the heterogeneity considered by Di Maggio and Kacperczyk (2014)–tends to be negative but not in a statistically significant way.

6.1 Investment Opportunities: Risk Premium vs. Risk-free Rate

Prime MMFs can invest only in U.S treasuries, GSE debt, repurchase agreements, certificate of deposits (i.e., time deposits and bank obligations), floating-rate notes, commercial papers, and asset-backed commercial papers. Among these eligible securities, U.S. treasuries, GSE debt, and repos are the safest ones. Certificates of deposits (CDs), floating-rate notes (FRNs), commercial papers (CPs) and asset-backed commercial papers (ABCPs) have historically been the riskiest ones.

To investigate the time variation in the investment opportunities available to MMFs, I construct an index of spreads on the risky securities available to MMFs. The index contains the 3-month CD rate, 3-month LIBOR (often used as reference rate for FRNs), 3-month AA financial CP rate, and 3-month AA ABCP rate. Data are at the monthly level from FRED. The index is

$$Spread\ Index_t = \left(a^{CD}_{2006}\, r^{CD}_t + a^{FRNS}_{2006}\, r^{LIBOR}_t + a^{CP}_{2006}\, r^{CP}_t + a^{ABCP}_{2006}\, r^{ABCP}_t\right) - GS3M_t \qquad (6)$$

where r^K_t is the interest rate of category K in month t, and $GS3M_t$ is the 3-month constant maturity rate on T-bills (from FRED). The coefficient a^K_{2006} is the industry average relative weight of category K in the portfolios of institutional prime MMFs' as of January 3, 2006. Weights are held constant as of January 2006 to alleviate possible endogeneity issues. a's are normalized to sum up to 1. Figure 5 shows *Spread Index* (red line) from January 2006 to August 2008. Before July 2007, *Spread Index* was consistently below 0.5%, with an average value of 0.3%. From July 2007, *Spread Index* started to rise, reaching 1.4% in August 2007 and a maximum of 1.9% in August 2008, with an average value of 1.4% from August 2007 to August 2008.

Spread Index is an *ex post* measure of investment opportunities, which I use as secondary proxy for the risk premium. Figure 5 also shows my primary proxy for the risk premium, *GZ Premium* (blue line). The pattern is similar. Until July 2007, it was negative and relatively flat with an average value of -0.27%. In August 2007, it became positive and started to rise steadily, reaching a maximum of almost 2% in August 2008, with an average value of more than 0.9% from August 2007 to August 2008. The time paths of *Spread Index* and *GZ Premium* indicate that starting from July-August 2007 the premia available to prime MMFs experienced a significant increase. Hereafter, I refer to the period from January 2006 to July 2007 as the *Pre* period, and to the period from August 2007 to August 2008 as the *Post* period.

Figure 5 also shows the 1-month T-bill monthly return (green line) over the period of interest. The 1-month T-bill rate was relatively high in the pre period, with an average value of 40 basis points (bps), and decreased substantially in the post period, reaching a minimum of 9 bps in May 2008, with an average value of 22 bps. This evidence says that, in the period of analysis, low risk-free rates were associated with high risk premia, and *vice versa*. Importantly, note that the increase in risk premia started few months earlier than the decrease in the risk-free rate, which helps to identify the differential effect of these variables on fund risk-taking.

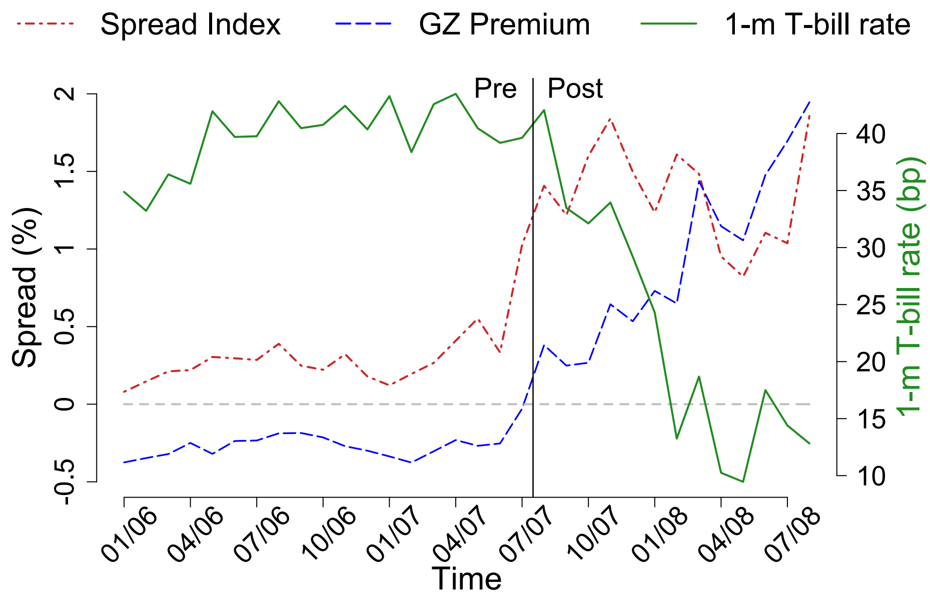


Figure 5: **Risk Premium vs. Risk-free Rate.** *Spread Index* (dot-dashed line) is an index of spreads on risky securities available to prime MMFs, weighted according to the industry average holdings as of January 3, 2006 (see (6)). *GZ Premium* (dashed line) is the the excess bond premium for financial firms from Gilchrsit and Zakrajsek (2012). The solid line, whose scale in on the righ y-axis, represent the monthly return on the 1-month T-bill. Data are monthly.

Proxies of risk-taking

Since *Spread Index* and *GZ Premium* aggregate risk premia across different instrument types, they do not identify the single, riskiest asset class available to MMFs in the period of analysis. In order to do that, since I do not observe fund portfolios at the individual security level, I run a panel regression with current fund spread on the left-hand side and past holdings by instrument category, together with a set of controls, on the right-hand side. Details on the regression specification are in Appendix E, and results are in Table E.1. I find that bank obligations experienced the largest increase in spread relative to U.S. treasuries in the post period and were the riskiest asset class over the whole period. In view of this result, I use the percentage holdings of bank obligations net of U.S. treasuries, GSE debt, and repurchase agreements as a measure of the riskiness of MMF portfolios in terms of asset class composition. I refer to this measure as *Holdings Risk* and use it as main proxy for fund risk-taking in my regressions.[32] In the following, I also use other proxies for fund risk-taking: $Maturity\ Risk$ and $Spread$. $Maturity\ Risk$, is the weighted average maturity of assets in a fund portfolio. In general, funds with longer portfolio maturities are considered riskier. $Spread$, is fund's gross yield minus the 1-month T-bill rate. In the context of MMFs, the spread is a good measure of risk because there is little scope for managerial skill, so that fund spreads largely reflect fund portfolio risk.[33]

Finally, for robustness purposes, I also use the share of U.S. treasuries, GSE debt, and repos as negative proxy for fund risk-taking. As mentioned above, these asset classes have consistently been the safest instruments available to prime MMFs. In the following, I refer to this (negative) measure of risk-taking as $Safe\ Holdings$.

6.2 The Flow-performance Relationship and the Tournament Assumption

This sections analyzes the flow-performance relation in the MMF industry during the period of analysis. In particular, it tests the assumptions that investor money flows are determined by the rank of fund performance (tournament), and not raw performance.

I estimate the sensitivity of fund flows to past performance using the following regression model:

$$Fund\ Flow_{i,t+1} = \alpha_i + \mu_t + \beta Performance_{i,t} + \gamma \cdot X_{it} + \varepsilon_{i,t+1} \tag{7}$$

where $Fund\ Flow_{i,t+1}$ is the percentage increase in fund i's size from week t to week $t+1$, adjusted for earned interests and trimmed at the 0.5% level to alleviate the concern of outliers. $Performance_{i,t}$ is a measure of fund i's performance in week t (see below). $X_{i,t}$ is a vector of fund-specific controls that includes the natural logarithm of fund size in millions of dollars ($Log(Fund\ Size)$), fund expenses in basis points ($Expense\ Ratio$), fund age in years (Age), the natural logarithm of the fund family size in billions of dollars ($Log(Family\ Size)$), and the volatility of fund flows ($Flow\ Volatility_{i,t}$), measured as the standard deviation of weekly fund flows over the previous quarter. μ_t denotes week fixed effects, which account for variations in the macroeconomic environment, and α_i denotes fund fixed effects, which account for any unobserved time-invariant fund characteristics within the pre or post periods. The coefficient of interest is β.

In my first specification, $Performance_{i,t}$ is the raw spread: $Spread_{i,t}$ is the annualized gross yield (i.e., before expenses) minus the yield of the 1-month T-bill, in basis points. Columns (1) and (2) of Table 1 show the results for this specification. Standard errors are heteroskedasticity-and-autocorrelation (HAC) robust.[34] When raw spreads are used as measure of performance, the

[32] KS obtained similar results and used the same measure of risk-taking in their empirical analysis.

[33] A potential problem with using this measure is that it may vary over time even though managers may not actively change the risk profile of their portfolios, only because the yields of individual assets in the portfolio change.

[34] Hereafter, unless otherwise specified, reported standard errors are always HAC robust, and all panel data models are estimated using the "within" estimator.

flow-performance relation is positive and significant only in the post period.

In the MMF industry, however, cross-sectional spreads are typically very small and a difference of even few basis points can crucially alter fund flows. Hence, raw measures of past performance might not be appropriate to explain investor money flows. In my second specification, $Performance_{i,t}$ is the spread rank: $Spread\ Rank_{i,t}$ is the rank of fund i's spread in week t. The rank is expressed in percentiles normalized over the interval $[0, 1]$, with $Spread\ Rank = 0$ for the worst performance and $Spread\ Rank = 1$ for the best one. Columns (3) and (4) of Table 1 show the results.

When the spread rank is the main explanatory variable, the flow-performance relation is positive and statistically significant in both periods, and the adjusted R^2 slightly increases (by 0.1–0.2%). These results suggest that ranks are more important than raw performance in explaining money flows to MMFs. To further test this hypothesis, I estimate model (7) including both measures of performance. Columns (5) and (6) of Table 1 show the results.

When both raw spreads and spread ranks are included, the spread rank remains positive and statistically significant in both periods, while the raw spread is not statistically significant in either one. These results indicate that the performance rank, not the raw performance, is the actual determinant of fund flows in the MMF industry.[35] Moving from the lowest to the highest rank of past performance increases subsequent fund flows by 0.92% per week in the pre period and 1.79% per week in the post period. Both effects are economically large because they imply that a fund could increase its annual revenue by 60.9% in the pre period and 151.8% in the post period by moving from the lowest to the highest rank.[36]

As robustness check, I run regression (7) using the rank of *Fund Flow* as dependent variable to alleviate the concern of outliers, without resorting to trimming. Results are similar and reported in Table F.1 in Appendix F. As further robustness checks, I also run regression (7) trimming the distribution of fund flows at multiples of the interquartile range and/or using only time fixed effects. Results are similar and can be found in the online appendix.

In Appendix F, I also show that the flow-performance relation is not explicitly affected by the reputation concerns of fund sponsors. That is, investors do not risk-adjust a fund's yield based on the reputation concerns of its sponsor. This evidence shows that the flow-performance relation can be taken as exogenous in the context of my model. Similar results have also been obtained by KS.

[35] Massa (1997), and Patel, Zeckhauser, and Hendricks (1994) obtained similar results for equity mutual funds.

[36] An increase equal to the cross-sectional average of the within-fund standard deviation of *Spread Rank*, equal to a shift of 20% across the rank distribution, increases subsequent fund flows by 0.18% per week in the pre period, and 0.36% per week in the post period. These figures imply that a fund, by increasing its rank of 20%, could increase its annual revenue by 10.0% in the pre period and 20.4% in the post period.

6.3 Risk-taking in the Time Series: Who's Reaching For Yield?

This section provides empirical evidence in agreement with model's predictions on the level of MMF risky investment in the time series. The model predicts that an increase in the risk premium increases the risky investment of funds with lower default costs (if they face sufficiently high competition) but decreases the risky investment of funds with higher default costs. On the other hand, a decrease in the risk-free rate leads all funds to reduce their risky investment (with the effect being stronger for funds with higher default costs).

In the period from July 2007 to August 2008, there were both a decrease in risk-free rates and an increase in the premia of some securities available to MMFs because of an increase in their riskiness. Figure 1 in the Introduction shows the net risky investment (*Holdings Risk*) of funds whose sponsors have reputation concerns (*Fund Business*) consistently below the industry median (dashed red line) and funds whose sponsors have reputation concerns consistently above the industry median (solid blue line). In the context of my model, the first category represents funds with relatively low default costs, and the second one represents funds with relatively high default costs. Figure 1 shows that in the period of high risk premia (and low risk-free rates), there is a bifurcation in the risk-taking of MMFs, as predicted by the model: funds with lower default costs do "reach for yield," while funds with higher default costs do the opposite.

To give a more quantitative estimate of the above evidence, I perform the following analysis. I consider a sub-period with relatively high risk-free rates and low risk premia (July-December 2006), and a sub-period with relatively low risk-free rates high risk premia (January-June 2008). The average monthly return on 1-month T-bills was about 41.1 basis points from July to December 2006, and about 15.6 basis points from January to June 2008. The average monthly excess bond premium for financial firms, on the other hand, was about -0.19% from July to December 2006, and about 1.1% from January to June 2008. Table 2 reports summary statistics for the 1-month T-bill rate, *GZ Premium*, and *Spread Index* over the two periods. Then, I compare the average change over time in net risk exposure for funds with high *Fund Business* to the average change over time in net risk exposure for funds with low *Fund Business*. For roustness, I do the same for the average change over time in safe holdings. Results are in Table 3.

Table 3 confirms the qualitative observations of Fig. 1. For the funds with high reputation concerns the average change in net risk exposure across the two periods was -3.3 percentage points, and the average change in safe holdings was almost 3.7 percentage points. Both changes are statistically significant at the 1% level. On the contrary, for funds with low reputation concerns the average change in net risk exposure across the two periods is 4.7 percentage points, and the average change in safe holdings is 1.3 percentage points. The change in net risky investment is statistically significant at the 1% level, while the change in safe holdings is not statistically significant.[37] These

[37]Similar results hold also if we restrict the definition of *Safe Assets* to U.S. Treasuries and GSE debt.

preliminary results qualitatively confirm the predictions of my model on the risk-taking behavior of MMFs in the time series. This analysis, however, does not distinguish the effect of decreasing risk-free rates from that of increasing risk premia. In the next section, I try to disentangle the differential effects of risk-free rates and risk premia.

6.3.1 Disentangling the risk-free rate from the risk premium

The model predicts that, holding the risk-free rate constant, an increase in the premium and riskiness of the available risky securities increases the risky investment of funds with lower default costs and decrease that of funds with higher default costs (prediction P.2a, b). On the other hand, holding the premium constant, a decrease in the risk-free rate decreases the risky investment of all funds, with the effect being stronger for funds with higher default costs (prediction P.3a). This section aims to disentangle these two channels and shows evidence in support of model's predictions.

Hereafter, I consider only MMFs that remain in the data set throughout the whole period of analysis. There are 122 such funds. On this balanced panel, I consider the following regression:

$$\begin{aligned} Risk_{i,t} =& \alpha_i + \beta_1^H High\,FB_{i,t-1} * \widehat{rp}_t + \beta_2^H High\,FB_{i,t-1} * rf_t + \\ &+ \beta_1^L Low\,FB_{i,t-1} * \widehat{rp}_t + \beta_2^L Low\,FB_{i,t-1} * rf_t + \gamma \cdot X_{i,t-1} + \varepsilon_{i,t} \end{aligned} \tag{8}$$

$Risk$ is either $Holdings\,Risk$ or $Maturity\,Risk$ defined as in Section 6.1.[38] $\widehat{rp}$ is a proxy for the risk premium: *GZ Premium* in the main specification. rf is the return on 1-month T-bills. Since data on $\widehat{rp}$ are at the monthly level, weekly fund-specific data are averaged over months, and regression (8) is run at the monthly level. $High\,FB_{i,t}$ ($Low\,FB_{i,t}$) is a dummy variable that is equal to 1 if fund i's *Fund Business* is above (below) the industry median in month t and zero otherwise. X is the set of fund-specific controls defined in (7) with, in addition, sponsor's *Fund Business* and without *Flow Volatility*. All fund-specific right-hand side variables are lagged to alleviate possible endogeneity issues. α_i denotes fund fixed effects, which account for unobserved time-invariant fund characteristics.

β_1^H and β_2^H represent how the risky investment of MMFs with higher default costs (i.e., with higher sponsor's reputation concerns) responds to changes in the risk premium and risk-free rate, respectively. β_1^L and β_2^L represent the corresponding sensitivities for funds with lower default costs. The model predicts: $\beta_1^H < 0 < \beta_1^L$ and $\beta_2^H > \beta_2^L > 0$. For robustness, I also run regression (8) with *Safe Holdings* as dependent variable. In that case, the model predicts: $\beta_1^H > 0 > \beta_1^L$ and $\beta_2^H < \beta_2^L < 0$.

Columns (1)–(3) of Table 4 show the results. Since *Fund Business* is a fund sponsor attribute, risk-taking within the same sponsor may be correlated across its funds. To address this concern, reported standard errors are HAC and cross-correlation robust. As for the effect of changes in the

[38] Since *Spread* mechanically co-varies with the risk-free rate, I do not use it as measure of risk-taking in (8).

risk premium, the data confirm the predictions of the model for all measures of risk. For funds whose sponsors have *Fund Business* above the median, an increase of 1% in the risk premium decreases *Holdings Risk* by roughly 2%, increases *Safe Holdings* by 1.6%, and decreases *Maturity Risk* by 2.1 days. These results are statistically significant at the 1% level. On the contrary, funds whose sponsors have fund business below the median increase their *Holdings Risk* by 1.5% and their *Maturity Risk* by 1.2 days. These results are statistically significant at the 10% level.

As for the effect of changes in the risk-free rate, the data confirm the predictions of the model for the risk measures based on asset class holdings. After a decrease of 1% in the 1-month T-bill monthly return, funds whose sponsors have high *Fund Business* decrease their *Holdings Risk* by 3.2 percentage points and increase their safe holdings by 10.7 percentage points, with the result for safe assets being statistically significant at the 1% level. Funds whose sponsors have low *Fund Business* decrease their *Holdings Risk* by only 0.7 percentage points and increase their *Safe Holdings* by 8.6 percentage points, with the result for safe assets being statistically significant at the 10% level. For both categories of funds, the effect of the risk-free rate on safe assets is economically important.

Interestingly, the results for *MaturityRisk* suggest that the shift to safer asset classes is accompanied by a maturity extension. *Ceteris paribus*, after a decrease of 1% in the risk-free rate, both funds with relatively high and low default costs increase their portfolio maturity by roughly 7 days. This apparent disagreement with the model comes from the fact that: (1) longer maturity does not necessarily mean riskier portfolio, especially if shorter-term bank obligations are substituted by longer-term treasuries; (2) the model does not distinguish between maturity risk and holdings risk, and hence it cannot capture the trade-off between these two types of risk. Together with the observations on *Holdings Risk* and *Safe Holdings*, the results for *Maturity Risk* suggest that when risk-free rates decrease, funds do increase their safe holdings, but compensate to this loss of yield by increasing the maturity of their portfolio.[39]

As first robustness check, I run regression (8) identifying as funds with high (low) default costs those whose sponsors have *Fund Business* consistently above (below) the median *over the whole period* of analysis. This specification eliminates the concern that the results might be driven by endogenous changes in sponsors' reputation concerns in response to changes in the interest rate environment. Results are in columns (4)–(6) of Table 4 and are qualitatively similar to those in columns (1)–(3). When the risk premium increases, holding the risk-free rate constant, funds with higher default costs decrease their risky investment, while funds with lower default costs tend to do the opposite (even though not in a statistically significant way). When the risk-free rate decreases, holding the premium constant, all funds reduce risky investment and shift to safer assets, with the effect being statistically more significant for funds with higher default costs.

Another possible concern is that since reputation concerns are a sponsor's characteristic, the

[39] A similar behavior was qualitatively observed also by Baba, McCauley, and Ramaswami (2009).

cutoff between funds with high and low default costs should be calculated at the sponsor level. To address this issue, I run regression (8) using the median value of $Fund\ Business$ in the sponsor population as cross-sectional cutoff. Results are similar and reported in Tables G.6. Finally, I run regression (8) using $Spread\ Index$ as proxy for the risk premium, and the 3-month T-bill rate as proxy for the risk-free rate. Results are similar and can be found in the online appendix.

6.4 Risk Taking in the Cross-section

This section exploits the significant cross-sectional variation in sponsor's reputation concerns to test the predictions of the model on the risky investment of MMFs in the cross-section. My model predicts that funds whose sponsors have lower reputation concerns (i.e., lower default costs) always hold more risky assets (P.1), and that the cross-sectional differential increases when either the risk premium goes up (P.2c), or the risk-free rate goes down (P.3b).

On the balanced panel of MMFs active throughout the whole period of analysis, I estimate the following weekly regression:

$$Risk_{i,t} = \alpha_i + \mu_t + \beta_1 FB\ Rank_{i,t-k} + \beta_2 Post_t * FB\ Rank_{i,t-k} + \gamma \cdot X_{i,t-k} + \varepsilon_{i,t} \qquad (9)$$

where $FB\ Rank_{i,t}$ is the rank of fund i's $Fund\ Business$ in week t. $FB\ Rank$ is calculated at the fund level (i.e., two funds have the same $FB\ Rank$ if they have the same sponsor) and is expressed in percentiles normalized to $[0, 1]$. $FB\ Rank = 0$ for those funds whose sponsor has the lowest fund business, and $FB\ Rank = 1$ for those funds whose sponsor has the highest fund business. X is the set of fund-specific controls defined in (8), with in addition their interaction terms with $Post_t$ and $FB\ Rank$ instead of $Fund\ Business$. $Post$ is an indicator variable equal to 1 for the post period and 0 for the pre period. Both $FB\ Rank$ and X are lagged by k weeks to alleviate endogeneity concerns. For robustness, I run various regression specifications with different values of k, namely, $k = 1, 4, 8$, and 12 (corresponding to 1 week, 1 month, 2, and 3 months). μ_t and α_i denote week and fund fixed effects, respectively. I use three measures of risk ($Risk$) at a weekly frequency: $Holdings\ Risk$, $Maturity\ Risk$, and $Spread$, as defined in Section 6.1.

The coefficients of interest are β_1 and β_2. β_1 measures the effect of a sponsor's reputation concern on the risky investment of its funds in the pre period. β_2 measures the risk-taking differential between the post and the pre period. In the model, these coefficients correspond to the derivative of equilibrium risky investment w.r.t. the cost of default in different interest rate environments. Since in the post period there was a significant increase in risk premia and decrease in risk-free rates, the model predicts: $\beta_1 < 0$ and $\beta_2 < 0$.

Table 5 shows the result for $k = 4$ and 8. Reported standard errors are HAC and cross-correlation robust. For $Holdings\ Risk$ and $Maturity\ Risk$, both β_1 and β_2 are negative and statistically significant at the 1% level. These results are also economically important. Going from the highest to the lowest rank of *Fund Business* increases the net holdings of risky assets by 8.5 percentage points in the pre period and 17.7 percentage points in the post period, and it increases the portfolio maturity by 6.6 days in the pre period and 14 days in the post period. When *Spread* is the dependent variable, β_2 is negative and statistically significant, while β_1 is negative but insignificant.[40] Results for $k = 1$ and 12 are similar and omitted for brevity.

To address possible concerns about the above measures of risk, I also run regression (9) using the share of safe holdings (*Safe Holdings*) as dependent variable. In this case, the model predicts $\beta_1 > 0$ and $\beta_2 > 0$. Columns (7) and (8) of Table 5 show the results, which confirm the predictions of the model. Going from the highest to the lowest rank of *Fund Business* decreases the holdings of safe assets by 2.3 percentage points in the pre period and 7.7 percentage points in the post period, with the differential being statistically significant at the 1% level.

Since in the model risky investment is determined by a fund's rank in the distribution of default costs, the rank of sponsor's reputation concern, *FB Rank*, is the natural explanatory variable in regression (9). However, as robustness check, I also run regression (9) using raw *Fund Business* as main explanatory variable. Results are similar and can be found in Table G.2 in Appendix G.

To further check the robustness of my results, I run Instrumental Variable (IV) regressions in which *Fund Business* is instrumented with its lagged value, separately on the post and the pre period. The results are similar to those reported above and confirm the predictions of the model. Details on the regression specification are in Appendix G, and results are in Table G.3.

6.4.1 Disentangling the risk-free rate from the risk-premium

This section aims to disentangle the effect of changes in the level of the risk-free rate from the effect of changes in the risk premium on the cross-sectional risky investment differential. I.e., here I test predictions P.2c and P.3b separately. To this aim, I run the following regression:

$$Risk_{i,t} = \alpha_i + \mu_t + \beta_1 FB\ Rank_{i,t-1} * \widehat{rp}_t + \beta_2 FB\ Rank_{i,t-1} * rf_t + \gamma \cdot X_{i,t-1} + \varepsilon_{i,t} \tag{10}$$

where *Risk*, *FB Rank*, and X are defined as in (9), without the interaction terms with *Post*. $\widehat{rp}$ is a proxy for the risk premium: *GZ Premium* in the main specification. Since *GZ Premium* is estimated at the monthly level, regression (10) is also at the monthly level. Fund-specific weekly-observed quantities are averaged over months. rf_t is the risk-free rate, proxied by the 1-month T-bill return. Fund-level variables are lagged to alleviate possible endogeneity issues.

The coefficients of interest are β_1 and β_2. In the context of the model, β_1 represents the cross-derivative of fund risky investment w.r.t. the cost of default and the risk premium. β_2 represents

[40] The lack of statistical significance for *Spread* in the pre period could be due to the fact that: (1) spreads may change without the risk profile of the underlying portfolio changing, (2) the differential spread across eligible instruments was very small in the pre period, making identification more difficult.

the cross-derivative of fund risky investment w.r.t. the cost of default and the risk-free rate. The model predicts: $\beta_1 < 0$ (prediction P.2c) and $\beta_2 > 0$ (prediction P.3b). To check the robustness of my results, I also run regression (10) using $Safe\ Holdings$, defined as in (9), as dependent variable. In this case the model predicts: $\beta_1 > 0$ and $\beta_2 < 0$.

Results are in Table 6. Reported standard errors are HAC and cross-correlation robust. The data confirms the predictions of the model. When only either one of the interaction terms is included in regression (10), the sign of the coefficient is consistent with the model and the coefficient is statistically significant at the 1% level for all measures of risk. When both interaction terms are included, the sign of all coefficients is consistent with the model, but statistical significance and economic importance depend on the specific measure of risk.

For $Holdings\ Risk$ and $Safe\ Holdings$, only the interaction term with the risk premium is statistically significant, and it is also economically important. After an increase of 1% in the risk premium, the difference in net risk exposure between funds in the lowest and highest percentile of $Fund\ Business$ increases by 6.2 percentage points. Similarly, the difference in safe assets between funds in the highest and lowest percentile of $Fund\ Business$ increases by 3.6 percentage points. The cross-sectional effect of the risk-free rate is not statistically significant for either $Holdings\ Risk$ or $Safe\ Holdings$, but it is economically significant for $Holdings\ Risk$. After a decrease of 1% in the risk-free rate, the difference in net risk exposure between funds in the lowest and highest percentile of $Fund\ Business$ increases by more than 4.7 percentage points.

For $Maturity\ Risk$ and $Spread$, only the interaction term with the risk-free rate is statistically significant (at the 1% and 10% level, respectively). Its economic importance is also much greater than that of the interaction term with the risk premium. A decrease of 1% in the 1-month T-bill return increases the difference in portfolio maturity between funds in the lowest and highest percentile of $Fund\ Business$ by more than 20 days. On the other hand, an increase of 1% in the risk premium increases the same differential by only 1.6 days. A decrease of 1% in the 1-month T-bill return increases the spread differential between funds in the lowest and highest percentile of $Fund\ Business$ by almost 15 bps. On the other hand, an increase of 1% in the risk premium increases the same differential by only 0.4 bps.

These results suggest that the risk premium and the risk-free rate affect the risk-taking of MMFs in different ways. Changes in the risk premium are more important in determining the asset class composition of MMF portfolios. Changes in the risk-free rate, on the other hand, are more important in determining the weighted average maturity of MMF portfolios.

As first robustness check, I run regression (10) using $Fund\ Business$ instead of its rank as main explanatory variable. Results are similar and can be found in the online appendix. As further robustness checks, I run regression (10) using the 3-month T-bill rate as proxy for rf, and $Spread\ Index$ as proxy for $\widehat{rp}$. Results are reported in Table G.4 and Table G.5 of Appendix G, respectively. Again, they confirm model's predictions.[41] Finally, I run regression (10) interacting also the fund-specific controls with rf and $\widehat{rp}$, and/or lagging all fund-specific variables on the RHS by 2 months. Results are similar and omitted for brevity.

7 Conclusions

In this paper, I propose a novel tournament model of money market funds (MMFs) to study whether competitive factors generate "reach for yield" in a low risk-free rate environment. First, the model shows that competitive pressure is heterogeneous in the cross-section: funds with lower default costs face a higher competitive pressure and therefore take on more risk. Second, the model shows that it is important to distinguish low risk-free rates from high risk premia. The risk premium is key to trigger fund risk-taking. However, its effect is heterogeneous in the cross-section. When the premium increases due to an increase in the riskiness of the risky asset, funds with lower default costs increase their risky investment because, facing higher competitive pressure, they are more sensitive to the increase in investment opportunities. Funds with higher default costs, on the other hand, decrease they risky investment because, aiming to keep the default probability closer to zero, they are more sensitive to the increase in the probability of negative return realizations. On the other hand, contrary to conventional wisdom, a decrease in the risk-free rate reduces the risky investment of all funds, with the effect being stronger for funds with higher default costs. This is because a decrease in the level of the risk-free rate increases the buffer of safe assets necessary to keep the probability of default at the equilibrium level.

The empirical analysis shows that these predictions are consistent with the risk-taking behavior of MMFs during the 2006–2008 period. When risk premia increased, funds whose sponsors have low reputation concerns increased risk-taking, while funds whose sponsors have high reputation concerns decreased risk-taking. The empirical analysis also confirms the differential role of risk-free rate and spread to explain changes in fund portfolios. Holding the premium constant, when risk-free rates decreased, funds shifted their portfolios toward safer asset classes. Finally, I show that the rank of fund performance, not the raw performance, determines investor money flows in the industry, justifying the modeling assumption of a fund tournament.

These results shed light on the transmission of monetary policy to money market funds. The level of the risk-free rate affects fund risk-taking through the stable NAV and consequent risk of "breaking the buck" typical of money market funds. This channel of monetary policy, peculiar to MMFs, goes in the opposite direction of the conventional "reach for yield" argument and reduces fund risk-taking in a low risk-free rate environment. This result contributes to the recent debate on the systemic importance of MMFs and the new regulation recently approved by the SEC. Under

[41] Not surprisingly, the relative weights of risk premium and risk-free rate change. See Appendix G for details.

the new regulation, taking effect in October 2016, institutional prime funds will move from a stable NAV to a floating NAV. This institutional change, while possibly eliminating the risk of runs, might actually lead all institutional prime MMFs to take on more risk.

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	$Fund\ Flow_{i,t+1}$					
	(1)	(2)	(3)	(4)	(5)	(6)
	Post	Pre	Post	Pre	Post	Pre
$Spread\ Rank_{i,t}$			1.897^{***}	0.651^{**}	1.792^{**}	0.919^{**}
			(0.371)	(0.276)	(0.740)	(0.431)
$Spread_{i,t}$	0.026^{***}	0.027			0.002	−0.022
	(0.008)	(0.019)			(0.015)	(0.029)
$Log(Fund\ Size)_{i,t}$	-5.488^{***}	-4.163^{***}	-5.575^{***}	-4.181^{***}	-5.576^{***}	-4.186^{***}
	(0.893)	(0.662)	(0.912)	(0.669)	(0.912)	(0.671)
$Expense\ Ratio_{i,t}$	−0.094	−1.275	0.562	−1.241	0.491	−1.071
	(2.418)	(3.366)	(2.470)	(3.339)	(2.511)	(3.383)
$Age_{i,t}$	−0.120	-0.491^{**}	−0.139	-0.498^{**}	−0.137	-0.495^{**}
	(0.132)	(0.233)	(0.133)	(0.233)	(0.132)	(0.232)
$Flow\ Volatility_{i,t}$	-0.037^{***}	2.919^{**}	-0.015^{***}	2.843^{**}	−0.017	2.818^{**}
	(0.010)	(1.369)	(0.004)	(1.384)	(0.015)	(1.392)
$Log(Family\ Size)_{i,t}$	0.843^{*}	−0.009	0.841^{*}	−0.002	0.843^{*}	0.010
	(0.444)	(0.176)	(0.453)	(0.175)	(0.453)	(0.183)
Week fixed effect	Y	Y	Y	Y	Y	Y
Fund fixed effect	Y	Y	Y	Y	Y	Y
Observations	7,387	9,467	7,387	9,467	7,387	9,467
Adj. R^2 (within)	0.030	0.023	0.032	0.024	0.032	0.024
R^2 (overall)	0.079	0.060	0.080	0.061	0.080	0.061

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 1: **Flow-performance relation: performance rank matters more than raw performance.** Columns (1), (3) and (5) cover the period 8/1/2007-8/31/2008 (*post* period). Columns (2), (4) and (6) cover the period 1/1/2006-7/31/2007 (*pre* period). The dependent variable is $Fund\ Flow$, computed as the percentage change in total net assets from week t to week $t+1$, adjusted for earned interests and trimmed at the 0.5%. Independent variables are the weekly annualized spread from $t-1$ to t, its rank in percentiles normalized to $[0,1]$, logarithm of fund size, fund expense ratio, fund age, volatility of fund flows based on past 12-week fund flows, and logarithm of fund family size. All regressions are at the weekly level and include week and fund fixed effects. Standard errors are HAC robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

Period	1-month T-bill monthly return (bp)					
	Min	1st Qu.	Median	Mean	3rd Qu.	Max.
Jul-Dec 2006	39.76	40.39	40.61	41.10	42.01	42.83
Jan-Jun 2008	9.46	11.00	15.38	15.58	18.39	24.30
	GZ Premium (%)					
	Min	1st Qu.	Median	Mean	3rd Qu.	Max.
Jul-Dec 2006	−0.300	−0.271	−0.224	−0.232	−0.188	−0.186
Jan-Jun 2008	0.649	0.730	1.102	1.108	1.437	1.476
	Spread Index (%)					
	Min	1st Qu.	Median	Mean	3rd Qu.	Max.
Jul-Dec 2006	0.179	0.222	0.267	0.274	0.322	0.389
Jan-Jun 2008	0.822	0.953	1.170	1.201	1.484	1.609

Table 2: **Summary Statistics for risk-free rate and risk premium.** *GZ Premium* is the excess bond premium for financial firms from Gilchrist and Zakrajsek (2012). *Spread Index* is the index of spreads on eligible risky securities defined by (6).

Fund Business	*Holdings Risk* (%)			*Safe Holdings* (%)		
	Jul-Dec 06	Jan-Jun 08	Δ_t	Jul-Dec 06	Jan-Jun 08	Δ_t
High ($N = 39$)	-4.37^{***}	-7.67^{***}	-3.30^{***}	16.74^{***}	20.40^{***}	3.66^{***}
	(0.14)	(0.24)		(0.11)	(0.25)	
Low ($N = 50$)	0.64	5.37^{***}	4.73^{***}	16.51^{***}	17.87^{***}	1.36
	(0.97)	(0.40)		(0.65)	(0.52)	
$\Delta_t(High) - \Delta_t(Low)$			-8.03^{***}			2.30^{***}
t-stat			−7.40			2.63

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 3: **Risky investment over time: high vs. low default costs.** The sample includes all prime institutional funds continuously active throughout the period from 1/1/2006 to 08/31/2008 and whose sponsor's *Fund Business* is consistently either above (*High*) or below (*Low*) the industry median. *Fund Business* is the share of mutual fund assets other than institutional prime MMFs in sponsor's total mutual fund assets. *Holdings Risk* is the percentage of risky assets (i.e., bank obligations) net of the safe assets (US treasuries, GSE debt, and repos) in fund portfolios. *Safe Holdings* is the percentage of safe assets in fund portfolios. Δ_t is the average change over time. Standard errors of each within-period average (in parentheses) are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

	High (*Low*) *Fund Business* at $t-1$			*High* (*Low*) *Fund Business* over whole period		
	(1)	(2)	(3)	(4)	(5)	(6)
	Holdings Risk	*Maturity Risk*	*Safe Holdings*	*Holdings Risk*	*Maturity Risk*	*Safe Holdings*
$High\, FB_{i,t-1} * \widehat{rp}_t$	-1.955^{***}	-2.111^{***}	1.584^{***}	-3.416^{***}	-0.596	2.159^{***}
	(0.694)	(0.627)	(0.573)	(0.671)	(0.680)	(0.512)
$Low\, FB_{i,t-1} * \widehat{rp}_t$	1.545^{*}	1.150^{*}	-0.006	1.448	1.078	-0.073
	(0.909)	(0.682)	(0.861)	(1.395)	(1.157)	(1.219)
$High\, FB_{i,t-1} * rf_t$	3.199	-7.642^{*}	-10.662^{***}	8.159^{**}	-0.351	-11.632^{***}
	(4.316)	(4.035)	(3.914)	(3.223)	(3.592)	(3.481)
$Low\, FB_{i,t-1} * rf_t$	0.670	-7.101^{*}	-8.579^{*}	2.609	-9.396	-13.768^{*}
	(5.921)	(4.076)	(5.122)	(8.223)	(6.179)	(7.984)
$Controls_{i,t-1}$	Y	Y	Y	Y	Y	Y
Fund Fixed Effects	Y	Y	Y	Y	Y	Y
Adj. R^2 (within)	0.062	0.084	0.050	0.074	0.079	0.059
R^2 (overall)	0.757	0.568	0.753	0.759	0.566	0.755
Observations	3,782	3,782	3,782	3,782	3,782	3,782

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 4: **Reach for yield: risk premium vs. risk-free rate.** The sample is all U.S. institutional prime money market funds continuously active throughout the period from 1/1/2006 to 8/31/2008 ($n = 122$). Data are at the monthly level ($T = 31$). The dependent variables are: the percentage of risky assets (bank obligations) net of safe assets (US treasuries, GSE debt, and repos) in a fund's portfolio (*Holdings Risk*) in columns (1) and (4), average portfolio maturity (*Maturity Risk*) in columns (2) and (5), and the percentage of safe assets in a fund's portfolio (*Safe Holdings*) in columns (3) and (6). The risk premium $\widehat{rp}$ is the excess bond premium for financial firms from Gilchrist and Zakrajsek (2012). The risk-free rate rf_t is the return on 1-month T-bills. In columns (1)–(3), *High* (*Low*) $FB_{i,t}$ is a binary variable equal to 1 if fund i's *Fund Business* is above (below) the median value in month t, and 0 otherwise. In columns (4)–(6), *High* (*Low*) $FB_{i,t}$ is a binary variable equal to 1 for all t if fund i's *Fund Business* is above (below) the median value consistently over the whole period, and 0 otherwise. *Fund Business* is the share of mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. Other independent variables (*Controls*) are fund assets, expense ratio, fund age, fund family size, and *Fund Business*. All regressions include fund fixed effects. Standard errors are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

	$Holdings\ Risk_{i,t}$		$Maturity\ Risk_{i,t}$		$Spread_{i,t}$		$Safe\ Holdings_{i,t}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	k=4	k=8	k=4	k=8	k=4	k=8	k=4	k=8
$FB\ Rank_{i,t-k}$	−8.523***	−7.868***	−6.637***	−5.828***	−1.923	−1.965	2.315	1.664
	(1.805)	(1.732)	(1.434)	(1.596)	(1.995)	(1.969)	(1.591)	(1.644)
$FB\ Rank_{i,t-k} * Post_t$	−9.210***	−8.756***	−7.426***	−7.361***	−4.113***	−4.186***	5.424***	5.120***
	(1.504)	(1.481)	(0.932)	(0.978)	(0.743)	(0.791)	(0.952)	(0.918)
$Controls_{i,t-k}$	Y	Y	Y	Y	Y	Y	Y	Y
$Controls_{i,t-k} * Post_t$	Y	Y	Y	Y	Y	Y	Y	Y
Week Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Fund Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Observations	16,470	15,982	16,470	15,982	16,470	15,982	16,470	15,982
Adj. R^2 (within)	0.032	0.030	0.049	0.045	0.038	0.034	0.024	0.023
R^2 (overall)	0.759	0.762	0.588	0.591	0.983	0.983	0.756	0.758

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 5: **Cross-sectional risk-taking differential in the** *Pre* **and** *Post* **period.** The sample is all U.S. institutional prime money market funds continuously active throughout the period from 1/1/2006 to 8/31/2008 ($n = 122$). Data are at the weekly level ($T = 139$). The dependent variables are: the percentage of risky assets (bank obligations) net of safe assets (US treasuries, GSE debt, and repos) in a fund's portfolio (*Holdings Risk*) in columns (1)–(2), average portfolio maturity (*Maturity Risk*) in columns (3)–(4), the weekly annualized fund spread (*Spread*) in column (5)–(6), and the percentage of safe assets in a fund's portfolio (*Safe Holdings*) in columns (7)–(8). *FB Rank* is the rank in percentiles normalized to $[0, 1]$ of *Fund Business*, where *Fund Business* is the share of mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. *Post* is an indicator variable equal to 1 for the period from 8/1/2007 to 8/ 31/2008, and 0 otherwise. The other independent variables (*Controls*) are fund assets, expense ratio, fund age, and fund family size. All regressions are at the weekly level and include week and fund fixed effects. Standard errors are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Holdings Risk	*Safe Holdings*	*Holdings Risk*	*Safe Holdings*	*Holdings Risk*	*Safe Holdings*
$FB\,Rank_{i,t-1} * \widehat{rp}_t$	-6.865^{***}	3.688^{***}			-6.189^{***}	3.587^{**}
	(1.019)	(0.787)			(1.971)	(1.714)
$FB\,Rank_{i,t-1} * rf_t$			38.501^{***}	-20.285^{***}	4.718	−0.706
			(7.562)	(4.692)	(11.203)	(9.905)
Adj. R^2 (within)	0.049	0.028	0.046	0.026	0.049	0.028
R^2 (overall)	0.787	0.788	0.787	0.788	0.787	0.788
	Maturity Risk	*Spread*	*Maturity Risk*	*Spread*	*Maturity Risk*	*Spread*
$FB\,Rank_{i,t-1} * \widehat{rp}_t$	-4.568^{***}	-2.568^{***}			−1.637	−0.442
	(0.993)	(0.731)			(1.181)	(1.369)
$FB\,Rank_{i,t-1} * rf_t$			29.404^{***}	17.262^{***}	20.469^{***}	14.852^{*}
			(4.272)	(3.477)	(6.148)	(8.108)
Adj. R^2 (within)	0.031	0.010	0.033	0.011	0.033	0.011
R^2 (overall)	0.617	0.983	0.618	0.983	0.617	0.983
$Controls_{i,t-1}$	Y	Y	Y	Y	Y	Y
Month Fixed Effects	Y	Y	Y	Y	Y	Y
Fund Fixed Effects	Y	Y	Y	Y	Y	Y
Observations	3,782	3,782	3,782	3,782	3,782	3,782

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 6: **Cross-sectional risk-taking differential: risk premium vs. risk-free rate.** The sample is all U.S. institutional prime money market funds continuously active throughout the period from 1/1/2006 to 8/31/2008 ($n = 122$). Data are at the monthly level ($T = 31$). In the top panel, the dependent variables are: the percentage of risky assets (bank obligations) net of safe assets (US treasuries, GSE debt, and repos) in a fund's portfolio (*Holdings Risk*) in columns (1), (3), and (5), and the percentage of safe assets in a fund's portfolio (*Safe Holdings*) in columns (2), (4), and (6). In the bottom panel, the dependent variables are: average portfolio maturity (*Maturity Risk*) in columns (1), (3), and (5), the weekly annualized fund spread (*Spread*) in column (2), (4), (6). *FB Rank* is the rank in percentiles normalized to $[0, 1]$ of *Fund Business*, where *Fund Business* is the share of mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. $\widehat{rp}$ is the excess bond premium for financial firms from Gilchrist and Zakrajsek (2012). rf_t is the net return on 1-month T-bills. The other independent variables (*Controls*) are fund assets, expense ratio, fund age, and fund family size. All regressions include month and fund fixed effects. Standard errors are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

Appendix A Microfoundation of the tournament

This appendix presents a random utility model of fund investors that rationalizes the rank-based payoff function of the MMF tournament.

The standard theoretical justification for the empirically observed positive relation between money flows and past performance is that investors assume that fund managers have idiosyncratic, unobservable skills and try to infer them from historical data. Higher past performance is perceived as a signal of higher ability and generates money inflows.

Let us assume that there is a continuum of investors. Each investor is associated with a single fund and endowed with a wealth $D > 0$. I refer to the investor associated with fund c as "investor c". I assume that investor c has only two options: she can either put her money into her idiosyncratic fund c or invest in an alternative technology outside the MMF industry. The investor demand for delegated management satisfies the following random utility model:

$$\text{investor } c \text{ invests in} \begin{cases} \text{fund } c & \text{with probability} \quad p = Rk_\pi(c) \\ \text{alternative technology} & \text{with probability} \quad 1 - p \end{cases}$$

This model can be motivated by arguing that investors have limited information, or limited capacity of processing information, on the management industry and market structure. Each investor has accumulated some information on a given fund, which she prefers to the others for some idiosyncratic reason. Investor c uses the ex post rank of fund c's performance as an indication of its manager's skill. The acquisition of ex post information on other funds is too costly. Hence, each investor only decides whether to invest in the idiosyncratic fund or in the alternative technology.

There are other ways to endogeneize the rank-based flow-performance relation observed in the data as the outcome of an optimal investment strategy of rational investors. Huang, Wei,and Yan (2007) formally show that rank-based reward functions arise in equilibrium due to information acquisition and participation costs faced by retail investors. Matejka and McKay (2013) show that the logit model (closely related to the above random utility model) is the optimal decision rule for a rationally inattentive agent who is uncertain on the fundamental value of her investment possibilities but faces a cost of acquiring information. In the context of my model, the unobservable, fundamental value of investment opportunities would be a fund's underlying quality, and the logit model would represent the endogenous rank based flow-performance relation. Frankel (2013) shows that ranking is the optimal delegated alignment contract when a principal delegates multiple decisions to an agent, who has private information relevant to each decision, but the principal is uncertain about the agent's preferences. In the case of mutual fund industry, we can think of the principal as the investor and the agent as a financial adviser. Finally, the normative literature on tournament theory (e.g., Lazaer and Rosen, 1981) shows that a tournament reward structure is optimal for a principal-agent problem in presence of moral hazard.

Appendix B Relative Performance vs. Absolute Performance

This section compares fund risk-taking under the tournament to fund risk-taking under absolute performance compensation. As in the tournament, funds have initial deposits $D > 0$ that pay a gross interest rate equal to 1 to some outside investors. Funds can invest only in a risk-free asset with gross return $R_f > 1$ and a risky asset with a random gross return $R \sim F_R$ on $[\underline{R}, \overline{R}] \subseteq \mathbb{R}_+$. Let us assume that the risky asset has a positive risk premium in the standard sense, i.e. $\mathbb{E}[R] > R_f$, so that the funds have an incentive to take on risk. As in the fund tournament, F_R is assumed to be absolutely continuous, and f_R denotes its density.

Each fund receives a payoff proportional to the raw profit on its portfolio if it does not default, and it pays a fixed cost otherwise. For consistency with the tournament, funds are risk-neutral, the payoff is a linear function of the net profit, and each fund faces an idiosyncratic cost of default, $c \in (0, \infty)$. The payoff of fund c for investing x in the risky asset is

$$\upsilon_c(x) = \gamma \mathbb{E}_R\left[\pi(x) | \pi(x) \geq 0\right] \mathbb{P}_R\left(\pi(x) \geq 0\right) - c\mathbb{P}_R(\pi(x) < 0) \tag{11}$$

where $\gamma \in (0, 1)$ can be regarded as a percentage fee on profits, and $\pi(x)$ is fund's profit and is referred to as the absolute performance. Funds maximize (11) under no short-selling and no borrowing constraints. Contrary to what happens in the fund tournament, here the distribution of default costs plays no role in the optimization problem. Under absolute performance compensation, there are no strategic interactions among funds.

The maximization of (11) is a linear optimization problem on a bounded interval, with control variable $x \in [0, D]$. To simplify the analysis I make the following assumption.

ASSUMPTION 3. *(i)* $\inf_{r \in (\underline{R}, 1)} f_R(r) > 0$*; (ii)* $\sup_{r \in (\underline{R}, 1)} f_R(r) < \infty$.

Assumption 3 is weak. Several common distributions with support in $\mathbb{R}_+$ satisfy it, including uniform, exponential, Beta(1, β), Gamma(1, θ), and generalized Pareto. Moreover, for any absolutely continuous distribution F_R that does not satisfy Assumption 3 (i), we can construct another absolutely continuous distribution that is practically identical to F_R and satisfies Assumption 3 (i) by infinitesimally increasing f_R in an arbitrarily small neighborhood of its infima.[42]

Proposition 8. *Let Assumption 3 hold. The optimal risky investment of a fund maximizing the payoff function (11), subject to no short-selling and no borrowing constraints, is as follows.*

(i) If $\inf_{(\underline{R}, 1)} \frac{f_R'}{f_R} < \frac{2}{R_f - \underline{R}}$, *there exists a unique* $c_0 \in (0, \infty)$ *s.t.*

$$x(c) = \begin{cases} D & \text{for } c \leq c_0 \\ x_0 & \text{for } c > c_0 \end{cases}$$

[42] Since F_R is assumed to be absolutely continuous, the set $\{r \in [\underline{R}, \overline{R}] : f_R(r) = 0\}$ has zero Lebesgue measure, and therefore this modification would have a practically negligible effect on the distributional properties of R.

In this case the optimal strategy profile is said to be "bang-bang".

(*ii*) *In general, there exist* $c_1 \leq c_2 \in (0, \infty)$ *s.t.*

$$x(c) \begin{cases} = D & \text{for } c \leq c_1 \\ \in \{\widetilde{x} \in (x_0, D) | \widetilde{x} = h(\widetilde{x}; c) \text{ and } \widetilde{x} < g(\widetilde{x}; c)\} & \text{for } c_1 < c \leq c_2 \\ = x_0 & \text{for } c > c_2 \end{cases}$$

where $h(x;c) = \left(\frac{c\, D\, (R_f - 1)\, f_R(R_0(x))}{\gamma \mathbb{E}[R - R_f | R > R_0(x)] \mathbb{P}(R > R_0(x))}\right)^{1/2}$, $g(x;c) = \frac{(R_f-1)Dc}{2c + \gamma(R_f - 1)D} \frac{f'_R(R_0(x))}{f_R(R_0(x))}$, *and* $R_0(x) = R_f - (R_f - 1)D/x$. *Moreover,* $x(c)$ *is strictly decreasing on* (c_1, c_2).

If $\{\widetilde{x} \in (x_0, D) | \widetilde{x} = h(\widetilde{x}; c) \text{ and } \widetilde{x} < g(\widetilde{x}; c)\} = \varnothing$, $c_1 = c_2$ *and the optimal strategy profile is "bang-bang".*

Under no short-selling constraint the maximum achievable profit is bounded from above. If the cost of default is sufficiently high, the expected loss from default dominates the expected gain from absolute performance compensation, the fund invests exactly the maximum risky investment such that the probability of default is zero, x_0. On the other hand, if the cost of default is sufficiently low, the expected gain from absolute performance dominates the expected loss from default, and the fund invests its whole portfolio in the risky asset. These results are in contrast with those of the fund tournament. In that case, due to the strategic nature of the game, the pressure of competition drives all funds to invest more than x_0 in the risky security, so that the equilibrium default probability is strictly positive for all funds, regardless of the scale of default costs. On the other hand, in the tournament, funds with lower default costs do not invest their whole portfolio in the risky asset because, in equilibrium, they do not need that to outperform their competitors.

Corollary 6. *If the minimum cost of default in the industry is sufficiently high, equilibrium risk-taking in the fund tournament is strictly greater than optimal risk-taking under absolute performance compensation for all funds. (Except for that with the highest default cost for which optimal risk-taking is the same under the two compensation schemes.)*

In the MMF industry, the cost of default is arguably very high in absolute terms even for those funds with relatively lower default costs. Hence, Corollary 6 says that the competitive forces coming from the relative performance evaluation of MMFs by fund investors observed empirically generate more risk-taking than what there would be under absolute performance compensation.

Most predictions of the absolute performance model on the response of funds to shocks in the economic environment are different from the predictions of the tournament. Under absolute performance compensation, funds with (absolutely) high default costs are insensitive to shocks in the risk premium, and funds with (absolutely) low default costs are insensitive to both changes in the risk premium and changes in the risk-free rate.[43] This is in disagreement with the data. Moreover, by construction, the absolute performance model is unable to capture the effect of competitive pressure. Under the absolute performance model, fund risk-taking is insensitive to shifts in the distribution of default costs.

Appendix C Proofs

This appendix proves the theoretical results presented in the main text. Let us consider the following generalization of the *ex post* rank-order of profits

$$Rk_\pi(c) := \int_{\{c':\pi_{c'}<\pi_c\}} \mathrm{d}F_c(c') + \delta \int_{\{c':\pi_{c'}=\pi_c\}} \mathrm{d}F_c(c')$$

with $\delta \in [0,1]$. The results presented in the body of the paper are for the special case $\delta = 0$. δ represents the "premium" for pooling coming from investors' money flow. For risk-averse investors δ is arguably close to zero, since risk-averse investors would penalize the uncertainty about unobservable skills when a pool of funds have the same ex post profits.

Let us introduce the following notation: $\Omega := (\underline{c}, \overline{c})$ and $\lambda(\cdot)$ is the measure induced by $F_C(\cdot)$. I.e., for any $C = (c_1, c_2) \subseteq \Omega$ with $c_1 \leq c_2$, $\lambda(C) = F_C(c_2) - F_C(c_1)$. Since F_C is assumed to be absolutely continuous with respect to the Lebesgue measure, any set of Lebesgue measure zero has also measure zero under λ. As in the main text, I drop the "a.e." notation for simplicity; the following results on the properties of the equilibrium are to be interpreted as valid almost everywhere.

Lemma 2. *For a given strategy profile $x : \Omega \to [0, D]$, the objective function of player c is*

$$\begin{aligned} \upsilon_c(x) &= \gamma D \{a + F_R(R_f) + F_X(x)[1 - 2F_R(R_f)]\} - \{\gamma D [a + 1 - F_X(x)] + c\} F_R(R_0(x)) + \\ &\quad + \gamma D \{\delta [1 - F_R(R_0(x))] - F_R(R_f) + F_R(R_0(x))\} \lambda(C_x) \end{aligned}$$

where $R_0(x) := R_f - (R_f - 1)\frac{D}{x}$ and $C_x := \{c' \in \Omega : x(c') = x\}$.

Proof. Trivial (by substitution). □

Preliminary results

Lemma 3. *If there exists a Nash equilibrium $x : \Omega \to [0, D]$ s.t.*

$$x(c) \in \begin{cases} (x_0, D] & \text{for all } c \in C_1 \\ [0, x_0] & \text{for all } c \in \Omega \setminus C_1 \,, \end{cases}$$

[43] The results for funds with low default costs are due to the assumption of risk-neutrality. If the funds were risk-averse, we should expect the risk-taking of funds with low cost of default to be positively related with the premium and, holding the premium constant, with the risk-free rate.

then C_1 is connected, $\inf C_1 = \inf \Omega$*, and $x(c)$ is weakly decreasing on C_1 for all δ.*

Proof. By contradiction, suppose that there exist $c_1 \in \Omega$ and $c_2 \in C_1$ s.t. $c_1 < c_2$ and $x(c_1) < x(c_2)$. For notational simplicity let $x(c_1) = x_1$ and $x(c_2) = x_2$. Then,

$$\begin{aligned} \upsilon_{c_2}(x_1) &= \upsilon_{c_1}(x_1) - (c_2 - c_1)F_R\left(R_0(x_1)\right) \\ &\underset{\text{(by optimality of } \upsilon_{c_1}(x_1))}{\geq} \upsilon_{c_1}(x_2) - (c_2 - c_1)F_R\left(R_0(x_1)\right) \\ &= \upsilon_{c_2}(x_2) + \underbrace{(c_2 - c_1)}_{>0}\underbrace{\left[F_R\left(R_0(x_2)\right) - F_R\left(R_0(x_1)\right)\right]}_{>0} > \upsilon_{c_2}(x_2) \end{aligned}$$

which contradicts optimality of $\upsilon_{c_2}(x_2)$. Thus, $x(c)$ is weakly decreasing on C_1, C_1 is connected and $\inf C_1 = \inf \Omega$ for all δ. □

Lemma 4. *If there exists a Nash equilibrium $x : \Omega \to [0, D]$ s.t.*

$$x(c) \begin{cases} = D & \text{for all } c \in C_0 \\ \in (x_0, D) & \text{for all } c \in C_1 \\ \in [0, x_0] & \text{for all } c \in \Omega \setminus \{C_0 \cup C_1\}\ , \end{cases}$$

then, if $\delta < 1 - F_R(R_f)$,

(i) $C_0 \cup C_1 = \Omega$, i.e. $x(c) > x_0$ for all $c \in \Omega$;

(ii) C_0 is connected, C_1 is connected, $\inf C_0 = \inf \Omega$, $\sup C_0 = \inf C_1$, *and* $\sup C_1 = \sup \Omega$*;*

(iii) $x(c)$ is strictly decreasing on C_1 and continuous on the interior of C_1;

(iv) $\lim\limits_{c \to \sup \Omega} x(c) = x_0$ *if* $\sup \Omega > \gamma D \frac{\delta(1-F_R(1)) - F_R(R_f) - aF_R(1)}{F_R(1)}$.

Proof. (i) Let $C_2 := \Omega \setminus \{C_0 \cup C_1\}$. By contradiction, suppose that C_2 has positive Lebesgue measure, i.e. $\lambda(C_2) > 0$. Let us define

$$\widetilde{C} := \left\{c : \lambda\left(\left\{c' \in C_2 : x(c') \geq x(c)\right\}\right) > 0\right\} \subseteq C_2\,.$$

$\widetilde{C}$ is the subset of players whose risky investment is weakly smaller than the risky investment of a positive measure subset of players in C_2. By construction $\widetilde{C}$ is a subset of C_2 and has positive measure, i.e. $\lambda\left(\widetilde{C}\right) > 0$. For any $c_b \in \widetilde{C}$ let $x_b := x(c_b)$ and $\lambda_b := \lambda\left(\{c : x(c) = x_b\}\right)$. By construction $\lambda\left(C_2\right) - F_x(x_b) > 0$ and $\lambda\left(C_2\right) - F_x(x_b) - \lambda_b \geq 0$.

For sufficiently small $\varepsilon > 0$

$$\begin{aligned} \upsilon_{c_b}(x_0 + \varepsilon) &= \gamma D\left\{a + F_R(R_f) + \left[\lambda(C_2) + g(\varepsilon)\right]\left[1 - 2F_R(R_f)\right]\right\} + \\ &\quad - \left\{\gamma D\left[a + 1 - (\lambda(C_2) + g(\varepsilon))\right] + c_b\right\} F_R\left(R_0(x_0 + \varepsilon)\right) \end{aligned}$$

where $g(\varepsilon) := \lambda\left(\{c \in C_1 : x(c) < x_0 + \varepsilon\}\right) \geq 0$. Then, if $\delta < 1 - F_R(R_f)$, for all $c_b \in \widetilde{C}$ there exists a sufficiently small $\varepsilon > 0$ s.t.

$$\begin{aligned}
\upsilon_{c_b}(x_0+\varepsilon) \quad &\geq \quad \upsilon_{c_b}(x_b) + \gamma D\underbrace{\left[\lambda\left(C_2\right) - F_X(x_b) - \lambda_b\right]}_{\geq 0\text{, and } >0 \text{ if } \lambda_b = 0}\left[1 - 2F_R(R_f)\right] + \gamma D\lambda_b\underbrace{\left[1 - F_R(R_f) - \delta\right]}_{>0} + \\
&\quad - \left\{\gamma D\left[a + 1 - \lambda\left(C_2\right)\right] + c_b\right\}\underbrace{F_R(R_0(x_0+\varepsilon))}_{\approx 0 \text{ for small } \varepsilon} \\
&> \quad \upsilon_{c_b}(x_b)
\end{aligned}$$

which contradicts optimality of x_b. Note that optimality is violated by a positive measure set of players since $\lambda\left(\widetilde{C}\right) > 0$ by construction.

(ii) Trivial, it follows directly from (i) and Lemma 3.

(iii) *Monotonicity.* By contradiction, suppose that there exists a non-empty, non-singleton subset $C_a \subseteq C_1$ s.t. $x(c) = x_a \in (x_0, D)$ for all $c \in C_a$ and $x(c) \neq x_a$ otherwise. Since C_1 is connected and any NE is weakly decreasing on C_1, C_a has positive measure, i.e. $\lambda(C_a) > 0$. Pick $\varepsilon > 0$ and let $g(\varepsilon) := \lambda(\{c : x(c) \in (x_a, x_a + \varepsilon)\}) \geq 0$. Then, if $\delta < 1 - F_R$, for all $c_a \in C_a$ there exists a sufficiently small $\varepsilon > 0$ s.t.

$$\begin{aligned}
\upsilon_{c_a}(x_a+\varepsilon) \quad &= \quad \gamma D\left\{a + F_R(R_f) + \left[F_X(x_a) + \lambda\left(C_a\right) + g(\varepsilon)\right]\left(1 - 2F_R(R_f)\right)\right\} + \\
&\quad - \left\{\gamma D\left[a + 1 - F_X(x_a) - \lambda\left(C_a\right) - g(\varepsilon)\right] + c\right\} F_R\left(R_0(x_a+\varepsilon)\right) \\
&\geq \quad \upsilon_a(x_a) + \gamma D\underbrace{\lambda\left(C_a\right)}_{>0}\underbrace{\left[1 - F_R(R_f) - \delta\left(1 - F_R\left(R_0(x_a)\right)\right)\right]}_{>0 \text{ for all } x_a \in (0,D) \text{ if } \delta < 1 - F_R(R_f)} + \\
&\quad - \left\{\gamma D\left[a + 1 - F_X(x_a) - \lambda\left(C_a\right)\right] + c\right\}\underbrace{\Delta F_R\left(\varepsilon\right)}_{\approx 0} \\
&> \quad \upsilon_a(x_a)
\end{aligned}$$

for any $x_a \in (x_0, D)$, which contradicts optimality of x_a for a positive measure set of players.

(iii) *Continuity.* Let us prove that $x(c)$ is left-continuous. The proof of right-continuity is very similar and thus omitted. We proceed by contradiction. Let $\operatorname{int}(C_1)$ be the interior of C_1. Since $x(c)$ is strictly decreasing on C_1, let us suppose that there exists $c_1 \in \operatorname{int}(C_1)$ and $\eta > 0$ s.t. $x(c) > x(c_1) + \eta$ for all $c < c_1$. Pick $\varepsilon > 0$ and let $C_\varepsilon := (c_1 - \varepsilon, c_1)$. For notational simplicity let $x_1 := x(c_1)$, $\Delta F_R(\eta) := F_R\left(R_0(x_1 + \eta)\right) - F_R\left(R_0(x_1)\right) > 0$, and for all $c_\varepsilon \in C_\varepsilon$ let $x_\varepsilon := x(c_\varepsilon)$ and $g(\varepsilon) := \lambda((c_\varepsilon, c_1))$. Note that for ε sufficiently small $C_\varepsilon \subset C_1$ and, since $x(c)$ is strictly decreasing on C_1, $g(\varepsilon) = F_X(x_\varepsilon) - F_X(x_1)$. By absolute continuity of λ, there exists $\varepsilon > 0$ sufficiently small s.t. for all $c_\varepsilon \in C_\varepsilon$

$$\begin{aligned}
\upsilon_{c_\varepsilon}(x_1) \quad &= \quad \gamma D\left\{a + F_R(R_f) + F_X(x_1)\left[1 - 2F_R(R_f)\right]\right\} - \left\{\gamma D\left[a + 1 - F_X(x_1)\right] + c_\varepsilon\right\} F_R\left(R_0(x_1)\right) \\
&= \quad \upsilon_{c_\varepsilon}(x_\varepsilon) - \gamma D\underbrace{g(\varepsilon)}_{\approx 0}\left[1 - 2F_R(R_f) + F_R\left(R_0(x_\varepsilon)\right)\right] + \left\{\gamma D\left[a + 1 - F_X(x_1)\right] + c_\varepsilon\right\}\underbrace{\Delta F_R(\eta)}_{>0} \\
&> \quad \upsilon_{c_\varepsilon}(x_\varepsilon)
\end{aligned}$$

which contradicts the optimality of x_ε for a positive measure set of players.

(iv) First, let us prove that if $\sup \Omega > \gamma D \frac{\delta[1-F_R(1)]-F_R(R_f)-aF_R(1)}{F_R(1)}$, then $\lim_{c\to\sup\Omega} x(c) < D$. By contradiction, suppose that $\lim_{c\to\sup\Omega} x(c) = D$. Since $x(c)$ is weakly decreasing on $C_0 \cup C_1 = \Omega$, it must be $x(c) = D$ for all $c \in \Omega$. Under $\sup \Omega > \gamma D \frac{\delta[1-F_R(1)]-F_R(R_f)-aF_R(1)}{F_R(1)}$, by continuity of the payoff function with respect to fund's type c, there exists $\varepsilon > 0$ sufficiently small s.t. for all $c \in (\sup\Omega - \varepsilon, \sup\Omega)$

$$
\begin{aligned}
\upsilon_c(x_0) &= \gamma D\left[a + F_R(R_f)\right] \\
&= \upsilon_c(D) + \{\gamma D[a+1] + c\} F_R(1) - \gamma D\{\delta[1-F_R(1)] - F_R(R_f) + F_R(1)\} \\
&> \upsilon_c(D)
\end{aligned}
$$

which contradicts optimality of $x(c) = D$ for a positive measure set of players. Therefore, since $x(c) > x_0$ for all $c \in \Omega$, it must be $\lim_{c\to\sup\Omega} x(c) \in [x_0, D)$.

Now, by contradiction, suppose $\lim_{c\to\sup\Omega} x(c) = x_0 + \eta$ with $\eta > 0$. Pick $\varepsilon > 0$ small and let $C_\varepsilon := (\sup\Omega - \varepsilon, \sup\Omega) \subset C_1$. For notational simplicity let $x_\varepsilon := x(c_\varepsilon)$ for all $c_\varepsilon \in C_\varepsilon$. Since $x(c)$ is strictly decreasing on C_1, $F_X(x_\varepsilon) = 1 - F_C(c_\varepsilon)$ for all $c_\varepsilon \in C_\varepsilon$. By continuity of F_C there exists $\varepsilon > 0$ sufficiently small s.t. for all $c_\varepsilon \in C_\varepsilon$

$$
\begin{aligned}
\upsilon_c(x_0) &= \gamma D\left[a + F_R(R_f)\right] \\
&\geq \upsilon_c(x(c)) - \underbrace{[1 - F_C(c_\varepsilon)]}_{\approx 0 \text{ for small } \varepsilon}[1 - 2F_R(R_f)] + \{\gamma D[a + F_C(c_\varepsilon)] + c\} \underbrace{F_R(R_0(x_0+\eta))}_{>0} \\
&> \upsilon_c(x(c))
\end{aligned}
$$

which contradicts optimality of $x(c)$ for a positive measure set of players. □

Intuition If the "premium" for pooling is sufficiently small, "pooling" is not optimal because each player playing the pooling strategy can slightly increase her risky exposure so to increase the expected rank of her profits by outperforming, in expectation, the other pooling players, without significantly increasing the risk of default. It is obvious that this argument does not hold for $x(c) = D$ because of no-short-selling and no-borrowing constraints. On the other hand, the Nash equilibrium cannot have jumps because, under strict monotonicity, the marginal player on the left-hand side of a jump can decrease the risk of default by a finite amount without affecting the expected rank-order of her profits. By continuity of the payoff function with respect to fund's type, this is true for a positive measure set of players.

Proposition 9. *If there exists a Nash equilibrium $x : \Omega \to [0, D]$, then, if $\delta < \frac{F_R(R_f)-F_R(1)}{1-F_R(1)} < 1 - F_R(R_f)$,*

(i) $x(c) \in (x_0, D)$ for all $c \in \Omega$;

(ii) $x(c)$ *is strictly decreasing and continuous for all* $c \in \Omega$*;*

(iii) $\lim_{c \to \sup \Omega} x(c) = x_0$ *for any* $\sup \Omega \in \mathbb{R}_{>0}$*.*

Proof. (i). From Lemma 4 $x(c) \in (x_0, D]$ for all $c \in \Omega$. By contradiction, suppose there exists $C_a \subseteq \Omega$ with $\lambda(C_a) > 0$ s.t. $x(c) = D$ for all $c \in C_a$ and $x(c) < D$ otherwise. Pick $\varepsilon > 0$ and let $g(\varepsilon) := \lambda(\{c : x(c) \in (D - \varepsilon, D)\})$ and $\Delta F_R(\varepsilon) := F_R(1) - F_R((R_0(D - \varepsilon))$. Then, if $\delta < \frac{F_R(R_f) - F_R(1)}{1 - F_R(1)}$, by absolute continuity of F_C and F_R there exists a sufficiently small $\varepsilon > 0$ s.t. for all $c_a \in C_a$

$$\begin{aligned}
\upsilon_{c_a}(D - \varepsilon) &= \gamma D \{a + F_R(R_f) + [1 - \lambda(C_a) - g(\varepsilon)][1 - 2F_R(R_f)]\} + \\
&\quad - \{\gamma D [a + \lambda(C_a) + g(\varepsilon)] + c_a\} [F_R(1) - \Delta F_R(\varepsilon)] \\
&= \upsilon_{c_a}(D) + \gamma D \lambda(C_a) \underbrace{[F_R(R_f) - F_R(1) - \delta(1 - F_R(1))]}_{>0} + \\
&\quad + \{\gamma D [a + \lambda(C_a) + g(\varepsilon)] + c_a\} \underbrace{\Delta F_R(\varepsilon)}_{\approx 0} - \gamma D [1 - 2F_R(R_f) + F_R(1)] \underbrace{g(\varepsilon)}_{\approx 0} \\
&> \upsilon_{c_a}(D)
\end{aligned}$$

which contradicts the optimality of x_a for a positive measure set of players since $\lambda(C_a) > 0$.

(ii) It follows directly from (i) and Lemma 4.

(iii) Since $x(c) \in (x_0, D)$ is strictly decreasing and continuous on Ω, the proof is the same as the second part of the proof of Lemma 4 (iv), and thus it is omitted. □

Proof of results in the main text

Proof of Proposition 1. From Proposition 9 it follows that, under $\delta = 0$, any NE must be continuous and strictly decreasing. Let $x : \Omega \to (x_0, D)$ be a NE and let $x[\Omega] \subseteq (x_0, D)$ be its image. From strict monotonicity it follows that $F_X(y) = 1 - F_C(x^{-1}(y))$ for all $y \in x[\Omega]$, where $x^{-1}(\cdot)$ is the inverse of $x(\cdot)$. Under any NE the payoff function of fund c for investing $y \in x[\Omega]$ can be written as

$$\upsilon(y, c) = A(x^{-1}(y)) - B(x^{-1}(y), c)G(y)$$

where

$$\begin{aligned}
A(x^{-1}(y)) &= \gamma D \left\{a + F_R(R_f) + [1 - 2F_R(R_f)] \left[1 - F_C(x^{-1}(y))\right]\right\} \\
B(x^{-1}(y), c) &= \left\{\gamma D \left[a + F_C(x^{-1}(y))\right] + c\right\} \\
G(y) &= F_R(R_0(y))
\end{aligned}$$

By optimality of the NE, for any Δc

$$A(c) - B(c, c)G(x(c)) \geq A(c + \Delta c) - B(c + \Delta c, c)G(x(c + \Delta c))$$

and

$$A(c+\Delta c) - B(c+\Delta c, c+\Delta c)G(x(c+\Delta c)) \geq A(c) - B(c, c+\Delta c)G(x(c))$$

Since F_R is absolutely continuous by assumption and $R_0(\cdot)$ is continuously differentiable on (x_0, D), with strictly positive first derivative, by using the Mean Value Theorem on $G(\cdot)$ we can write

$$\frac{[A(c+\Delta c) - A(c)] - [B(c+\Delta c, c) - B(c,c)]\, G(x(c))}{B(c+\Delta c, c)G'(x^*)} \leq x(c+\Delta c) - x(c)$$

and

$$\frac{[A(c+\Delta c) - A(c)] - [B(c+\Delta c, c+\Delta c) - B(c, c+\Delta c)]\, G(x(c))}{B(c+\Delta c, c+\Delta c)G'(x^*)} \geq x(c+\Delta c) - x(c)$$

where $G'(\cdot)$ is the strctly positive first derivative of $G(\cdot)$, and $x^* \in (x(c), x(c+\Delta c))$. Combining the last two inequalities and dividing by $\Delta c > 0$, we obtain

$$\begin{aligned} \frac{[A(c+\Delta c) - A(c)] - [B(c+\Delta c, c+\Delta c) - B(c, c+\Delta c)]\, G(x(c))}{\Delta c\, B(c+\Delta c, c+\Delta c)G'(x^*)} &\geq \frac{x(c+\Delta c) - x(c)}{\Delta c} \\ \geq \frac{[A(c+\Delta c) - A(c)] - [B(c+\Delta c, c) - B(c,c)]\, G(x(c))}{\Delta c\, B(c+\Delta c, c)G'(x^*)} \end{aligned}$$

Because $x(c)$ is continuous, the left- and right-most terms of this double inequality converge to

$$\frac{A'(c) - B'(c,c)G(x(c))}{B(c,c)G'(x(c))}$$

as $\Delta c \to 0$, where $A'(\cdot)$ is the first derivative of $A(\cdot)$, and $B'(\cdot,\cdot)$ is the first derivative of $B(\cdot,\cdot)$ with respect to the first argument. By plugging the explicit expressions for A, B, and G, we obtain

$$\frac{\mathrm{d}x}{\mathrm{d}c} = -\frac{\gamma D f_C(c)\, [2q(R_f) + F_R\,(R_0(x(c)))]\, x(c)^2}{\{\gamma D\, [a + F_C(c)] + c\}\, f_R(R_0(x(c)))(R_f - 1)D} < 0\,.$$

where $q(R_f) := 0.5 - F_R(R_f)$. Therefore, $x(c)$ is continuously differentiable, strictly decreasing with strictly negative first derivative everywhere, and it must satisfy the above ODE. Note that the above ODE is the same ODE we would obtain by taking the first-order condition of the objective function under the assumption that the NE is continuously differentiable with strictly negative first derivative (so that the objective function would be continuously differentiable as well).

The boundary condition follows from Proposition 9 with $\delta = 0$. □

Proof of Proposition 2. From the proof of Porposition 1 we know that any NE is differentiable and must satisfy the following Dirichlet problem

$$\begin{cases} S(x)\mathrm{d}x + \widetilde{Q}(c)\mathrm{d}c = 0 \qquad \text{with } c \in \Omega \ \text{ and } \ x \in (x_0, D) \\ \lim\limits_{c \to \sup \Omega} x(c) = x_0 \end{cases}$$

where

$$S(x) = \frac{(R_f - 1)Df_R(R_0(x))x^{-2}}{2q(R_f) + F_R(R_0(x))}$$
$$\widetilde{Q}(c) = \frac{\gamma D f_C(c)}{\gamma D\left[a + F_C(c)\right] + c}$$

$S(x)$ is integrable on (x_0, D), and under $a > 0$ (or $\underline{c} > 0$) $\widetilde{Q}(c)$ is integrable on Ω. By integrating the above separable ODE we obtain

$$\int^c \widetilde{Q}(s)\mathrm{d}s = -\int^x \frac{(R_f-1)Df_R(R_0(u))u^{-2}}{2q(R_f)+F_R(R_0(u))}\mathrm{d}u + K = -\log\left[2q(R_f) + F_R(R_0(x))\right] + K$$

from which it follows

$$x(c) = \frac{(R_f - 1)D}{R_f - F_R^{-1}\left(\exp\left(-\int_{\underline{c}}^c \widetilde{Q}(s)\mathrm{d}s + K\right) - 2q(R_f)\right)}$$

where F_R^{-1} is the quantile function of R (i.e., the inverse of the cumulative distribution function). By using the boundary condition $\lim_{c\to\bar{c}} x(c) = x_0$ we derive $K = \int_{\underline{c}}^{\bar{c}} \widetilde{Q}(s)\mathrm{d}s + \log\left(2q(R_f)\right)$, and obtain the unique solution of the Dirichlet problem

$$x(c) = \frac{(R_f-1)D}{R_f - F_R^{-1}\left(2q(R_f)Q(c)\right)}. \tag{12}$$

where $Q(c) := \exp\left(\int_c^{\bar{c}} \widetilde{Q}(s)\mathrm{d}s\right) - 1$. Therefore, if there exists a NE, it is unique and equal to (12).

The next step is to check that $x(c) \in (x_0, D)$ for all c. From the boundary condition and the fact that $x(c)$ is continuous and strictly decreasing it follows that $x(c) > x_0$ for all $c \in \Omega$. It is easy to show that $x(c) < D$ for all $c \in \Omega$ if and only if

$$\int_{\underline{c}}^{\bar{c}} \widetilde{Q}(s)\mathrm{d}s = \mathbb{E}_C\left[\frac{\gamma D}{\gamma D\left[a + F_C(c)\right] + c}\right] < \log\left(1 + \frac{F_R(1)}{2q(R_f)}\right)$$

The last step is to prove that the unique solution of the Dirichlet problem is indeed a NE. Under the strategy profile (12) the objective function of each player, $\upsilon_c(y)$ with $y \in [0, D]$, is continuous everywhere and continuously differentiable on $[0, x_0) \cup (x_0, x(\underline{c})) \cup (x(\underline{c}), D]$. It straightforward to show that

$$\frac{\partial \upsilon_c}{\partial y}(y) = \begin{cases} 0 & \text{if } \ 0 \le y < x_0 \\ -\left[\gamma D a + c\right] f_R\left(R_0(y)\right)(R_f - 1)Dy^{-2} < 0 & \text{if } \ x(\underline{c}) < y \le D \end{cases}$$

The first derivative of $\upsilon_c(y)$ on $(x_0, x(\underline{c}))$ is given by

$$\begin{aligned} \frac{\partial \upsilon_c}{\partial y}(y) \quad &= \quad \gamma D\left[2q(R_f) + F_R(R_0(y))\right] f_C(x^{-1}(y)) \left(\left.\frac{\mathrm{d}x}{\mathrm{d}c}\right|_{c=x^{-1}(y)}\right)^{-1} \\ &\quad - \left\{\gamma D\left[a + F_C(x^{-1}(y))\right] + c\right\} f_R\left(R_0(y)\right)(R_f - 1)Dy^{-2} \end{aligned}$$

By substituting the above ODE we obtain

$$\frac{\partial v_c}{\partial y}(y) = \left(x^{-1}(y) - c\right) f_R\left(R_0(y)\right)(R_f - 1)Dy^{-2} \begin{cases} > 0 & \text{if } \; x_0 < y < x(c) \\ = 0 & \text{if } \; y = x(c) \\ < 0 & \text{if } \; x(c) < y < x(\underline{c}) \end{cases}$$

Since $v_c(y)$ is continuous everywhere, it follows that, under the strategy profile $x(\cdot)$ given by (12), $x(c)$ is a global maximum for all $c \in \Omega$. Therefore, $x(c)$ is the unique NE of the tournament. □

Proof of Lemma 1. Trivial, by applying Taylor's theorem on $q(R_f)$ around μ. □

Proof of Corollary 2. Trivial, by applying Taylor's theorem on $x^{NE}(c)$ around $\bar{c}$. □

Proof of Corollary 3. Trivial. □

Proof of Proposition 4. Let $F^{(i)}$ denote the distribution of risky returns, F_R, when the left tail is $H^{(i)}$. Let $x^{(i)}(c)$ be the NE under $H^{(i)}$ and $R_0^{(i)}(c)$ be the critical return, $R_0(x)$, calculated at $x^{(i)}(c)$.

(i) $\left[\frac{q^{(2)}}{q^{(1)}} \geq \sup \frac{H^{(2)}}{H^{(1)}}\right]$ For every c,

$$q^{(1)}Q(c) = F^{(1)}(R_0^{(1)}(c)) = F_R(1)H^{(1)}(R_0^{(1)}(c)) \geq \frac{q(1)}{q^{(2)}}F_R(1)H^{(2)}(R_0^{(1)}(c)) = \frac{q(1)}{q^{(2)}}F^{(2)}(R_0^{(1)}(c))$$

Hence, $q^{(2)}Q(c) \geq F^{(2)}(R_0^{(1)}(c))$, from which it follows that $R_0^{(2)}(c) \geq R_0^{(1)}(c)$, and therefore $x^{(2)}(c) \geq x^{(1)}(c)$.

(ii) $\left[\frac{q^{(2)}}{q^{(1)}} < \sup \frac{H^{(2)}}{H^{(1)}}\right]$ First, it is straightforward to prove (by contradiction) that $\frac{q^{(2)}}{q^{(1)}} < \sup \frac{H^{(2)}}{H^{(1)}}$ implies $\frac{q^{(2)}}{q^{(1)}} < \sup \frac{h^{(2)}}{h^{(1)}}$, where $h^{(i)}$ is the density of $H^{(i)}$.[44] Second, since $\frac{q^{(2)}}{q^{(1)}} > 1 > \inf \frac{h^{(2)}}{h^{(1)}}$ and $\frac{h^{(2)}}{h^{(1)}}$ is decreasing by LRD, there exists $r^* \in (\underline{R}, 1)$ s.t.

$$\frac{f^{(2)}}{f^{(1)}}(r) = \frac{h^{(2)}}{h^{(1)}}(r) \begin{cases} \leq q^{(2)}/q^{(1)} & \text{for all } r \geq r^* \\ > q^{(2)}/q^{(1)} & \text{for all } r < r^* \end{cases}$$

Since $R_0^{(1)}(c)$ goes to $\underline{R}$ as $c \to \bar{c}$, is continuous and strictly decreasing, there exists $c^* \in (\underline{c}, \bar{c})$ s.t., for all $c > c^*$,

$$\begin{aligned} F^{(2)}\left(G^{(1)}\left(q^{(1)}Q(c)\right)\right) &= \frac{f^{(2)}}{f^{(1)}}(\tilde{r})q^{(1)}Q(c) \quad \text{with } \tilde{r} \in (\underline{R}, r^*) \qquad \text{(by the Mean Value Theorem)} \\ &> q^{(2)}Q(c) \end{aligned}$$

[44]Since F_R is assumed to be absolutely continuous, $h^{(i)}$ is strictly positive for all $i = 1, 2$.

Hence, $> G^{(1)}\left(q^{(1)}Q(c)\right) > G^{(2)}\left(q^{(2)}Q(c)\right)$, and therefore $x^{(1)}(c) > x^{(2)}(c)$ for all $c > c^*$. Note that, if $Q(\underline{c}) = \mathbb{E}_C\left[(\gamma D\left(F_C(c)+a\right)+c)^{-1}\right] < \frac{F^{(1)}(r^*)}{q(1)}$, then $x^{(1)}(c) > x^{(2)}(c)$ for all c.

Now, consider the case when competitive pressure on funds with low cost of default is sufficiently high, i.e., $Q(\underline{c})$ is sufficiently large. By the single crossing property of LRD, there exists r^{**} s.t. $\frac{F^{(2)}}{F^{(1)}} = \frac{H^{(2)}}{H^{(1)}}$ is monotonically decreasing on $(r^{**}, 1)$. Since $\frac{q^{(2)}}{q^{(1)}} > 1 = \frac{F^{(2)}}{F^{(1)}}(1)$, there exists $Q(\underline{c})$ sufficiently large s.t. $R_0^{(1)}(\underline{c}) \in (r^{**}, 1)$ and

$$\frac{F^{(2)}}{F^{(1)}}(R_0^{(1)}(\underline{c})) < \frac{q^{(2)}}{q^{(1)}}$$

which implies $q^{(2)}Q(c) > F^{(2)}\left(R_0^{(1)}(\underline{c})\right)$, and hence $x^{(2)}(\underline{c}) > x^{(1)}(\underline{c})$. Then, by continuity and monotonicity of the NE, for $Q(\underline{c})$ sufficiently large there exists $c_* \in (\underline{c}, \overline{c})$ s.t. $x^{(2)}(\underline{c}) < x^{(1)}(\underline{c})$. □

Corollary 4. Trivial. □

Proof of Proposition 5. Trivial, by differentiating equilibrium (3) w.r.t R_f holding $q(R_f)$ constant. □

Proof of Proposition 6. Let $x(c; R_f)$ be the unique NE (3), where the second argument indicates the explicit dependence on the risk-free rate, R_f. Let

$$R_0^{NE}(c) := F_R^{-1}\left(2q(R_f)Q(c)\right) \quad \text{for all } c \in (\underline{c}, \overline{c})$$

be the equilibrium critical threshold of realized risky returns: at the uniqe NE (3), fund c "breaks the buck" if and only if $R < R_0^{NE}(c)$. Since $x(c) \in (x_0, D)$ is strictly decreasing and $\lim_{c\to\overline{c}} x(c) = x_0$, $R_0^{NE}(c) \in (\underline{R}, 1)$ is also strictly decreasing and $\lim_{c\to\overline{c}} R_0^{NE}(c) = \underline{R}$. Moreover, since F_R is absolutely continuous with support $(\underline{R}, \overline{R})$, $R_0^{NE}(c)$ is continuous on $(\underline{c}, \overline{c})$.

Since the probability density f_R is strictly positive everywhere on $(\underline{R}, \overline{R})$, the unique NE is differentiable with respect to R_f everywhere on $(\underline{c}, \overline{c})$, and

$$\frac{\mathrm{d}x(c;R_f)}{\mathrm{d}R_f} = \frac{2(R_f-1)f_R(R_f)}{2q(R_f)\left[R_f - R_0^{NE}(c)\right]^2}\left[\frac{(2q(R_f))(1-R_0^{NE}(c))}{2(R_f-1)f_R(R_f)} - \frac{F_R\left(R_0^{NE}(c)\right)}{f_R\left(R_0^{NE}(c)\right)}\right]$$

From Proposition 5 and the fact that $Q(\overline{c}) = 0$, it follows that $x(c)$ is strictly increasing with R_f in a neighborhood $I_{\overline{c}}$ of $\overline{c}$. Hence, $\frac{\mathrm{d}x(c;R_f)}{\mathrm{d}R_f}$ must be non-negative on $I_{\overline{c}}$ and strictly positive on a dense subset of $I_{\overline{c}}$. Therefore,

$$\begin{aligned} &\frac{F_R\left(R_0^{NE}(c)\right)}{f_R\left(R_0^{NE}(c)\right)} \le \frac{(2q(R_f))(1-R_0^{NE}(c))}{2f_R(R_f)(R_f-1)} \qquad \text{everywhere on } I_{\overline{c}}, \\ \text{and} \quad &\frac{F_R\left(R_0^{NE}(c)\right)}{f_R\left(R_0^{NE}(c)\right)} < \frac{(2q(R_f))(1-R_0^{NE}(c))}{2f_R(R_f)(R_f-1)} \qquad \text{on a dense subset of } I_{\overline{c}}. \end{aligned}$$

Since F_R/f_R is weakly increasing by assumption, the strict inequality holds true everywhere in a sufficiently small neighborhood of $\bar{c}$, i.e. for $R_0^{NE}(c)$ sufficiently close to $\underline{R}$.

If

$$\mathbb{E}_C\left[\frac{\gamma D}{\gamma D\left(a+F_C(c)\right)+c}\right] \leq \lim_{c\to\underline{c}}\log\left(1+F_R\left(1-\frac{2f_R(R_f)(R_f-1)}{2q(R_f)}\frac{F_R\left(R_0^{NE}(c)\right)}{f_R\left(R_0^{NE}(c)\right)}\right)\right),$$

then

$$\lim_{c\to\underline{c}}\frac{F_R\left(R_0^{NE}(c)\right)}{f_R\left(R_0^{NE}(c)\right)} \leq \lim_{c\to\underline{c}}\frac{(2q(R_f))(1-R_0^{NE}(c))}{2f_R(R_f)(R_f-1)}$$

in a neighborhood of $\underline{c}$, and from (weak) monotonicity of F_R/f_R it follows that $\frac{\mathrm{d}x(c;R_f)}{\mathrm{d}R_f} \geq 0$ for all c and $\frac{\mathrm{d}x(c;R_f)}{\mathrm{d}R_f} > 0$ almost everywhere on $(\underline{c},\bar{c})$.

On the other hand, if

$$\mathbb{E}_C\left[\frac{\gamma D}{\gamma D\left(a+F_C(c)\right)+c}\right] > \lim_{c\to\underline{c}}\log\left(1+F_R\left(1-\frac{2f_R(R_f)(R_f-1)}{2q(R_f)}\frac{F_R\left(R_0^{NE}(c)\right)}{f_R\left(R_0^{NE}(c)\right)}\right)\right),$$

then

$$\lim_{c\to\underline{c}}\frac{F_R\left(R_0^{NE}(\underline{c})\right)}{f_R\left(R_0^{NE}(\underline{c})\right)} > \lim_{c\to\underline{c}}\frac{(2q(R_f))(1-R_0^{NE}(c))}{2f_R(R_f)(R_f-1)}$$

and it follows that $\frac{\mathrm{d}x(c;R_f)}{\mathrm{d}R_f} < 0$ in a neighborhood of $\underline{c}$.

Since F_R/f_R is weakly increasing on $(\underline{R},1)$ by assumption and $R_0(c)$ is strictly decreasing, there exists a unique $c^* \in (\underline{c},\bar{c})$ s.t. $\frac{\mathrm{d}x(c;R_f)}{\mathrm{d}R_f} < 0$ for all $c < c^*$ and $\frac{\mathrm{d}x(c;R_f)}{\mathrm{d}R_f} > 0$ for all $c > c^*$. □

Proposition 7. If $F_C^{(2)} \succ_{LRD} F_C^{(1)}$, then there exists c^* s.t. $f^{(2)}(c) > f^{(1)}(c)$ for all $c > c^*$. Since $F_C^{(2)}(c) < F_C^{(1)}(c)$ for all c,

$$\int_c^{\bar{c}}\frac{\gamma D f_C^{(2)}(u)\mathrm{d}u}{\gamma D\left[F_C^{(2)}(u)+a\right]+u} > \int_c^{\bar{c}}\frac{\gamma D f_C^{(1)}(u)\mathrm{d}u}{\gamma D\left[F_C^{(1)}(u)+a\right]+u} \qquad \text{for all } c > c^*,$$

from which it follows that $Q^{(2)}(c) > Q^{(1)}(c)$ and therefore $x^{(2)}(c) > x^{(1)}(c)$ for all $c > c^*$

Using integration by parts,

$$\int_{\underline{c}}^{\bar{c}}\frac{\gamma D f_C(u)\mathrm{d}u}{\gamma D\left[F_C(u)+a\right]+u} = \log\left(\frac{\gamma D(a+1)+\bar{c}}{\gamma D\, a+\underline{c}}\right) - \int_{\underline{c}}^{\bar{c}}\frac{\mathrm{d}u}{\gamma D(F_C(u)+a)+u}.$$

Hence, if $F_C^{(2)}(c) < F_C^{(1)}(c)$ everywhere because $F_C^{(2)} \succ_{LRD} F_C^{(1)}$, $Q^{(2)}(\underline{c}) < Q^{(1)}(\underline{c})$. By continuity and monotonicity of the NE, there exists c_* s.t. $Q^{(2)}(c) < Q^{(1)}(c)$ and therefore $x^{(2)}(c) < x^{(1)}(c)$ for all $c < c_*$.

□

Appendix D Data Construction and Summary Statistics

Data Construction

Data on fund characteristics are from iMoneyNet. These data are the most comprehensive source of information on MMFs and are widely used for both academic research and investment decisions. KS check that the iMoneyNet database covers the universe of US MMFs by comparing it to the list of funds registered at the SEC, and Chodorow-Reich (2014) shows that the coverage of iMoneyNet data matches that of the Financial Accounts of the United States.

I focus on prime MMFs over the period from January 2006 to August 2008. Data are at the weekly, share class level. In my sample, there are a total of 830 share classes. I find that 7 of these share classes have some missing data for some week. Almost all missing data come from funds that report monthly for the first few months of their existence and later switch to weekly reporting. Following KS, I use linear interpolation to generate weekly data for these share classes. Since my analysis is at the fund level, I aggregate share classes at the fund level. To identify funds, I use information on the underlying portfolio, which must be the same for all share classes belonging to the same fund. Share classes that have the same portfolio composition in terms of asset classes and the same weighted average maturity identify a unique fund. Over my period of analysis, consisting of 139 weeks, I identify 330 prime MMFs. I double-check the accuracy of my fund identifier by verifying that the assets for all share classes add up to total fund size. The difference between the two exceeds \$100,000 (data are reported in \$100,000 increments) only for 177 fund-week observations out of $35,608$, i.e., less than 0.5% of the sample.

To construct fund level characteristics, I follow KS and average share class characteristics using share class assets as weights. Each fund can have both retail share classes, which are available only to retail investors, and institutional share classes, which are available only to institutional investors. In my empirical analysis, I label a fund as institutional if it has at least one institutional share classes. A fund is labeled as retail if it has no institutional share class. KS use the same convention. Moreover, institutional share classes are typically much larger than retail share classes, which justifies this identification. My empirical analysis focuses on institutional funds because it has been observed that they face a more sensitive flow-performance relation than retail funds. In my sample, I observe 192 institutional funds, for a total of $19,642$ institutional fund-week observations. (I observe 149 retail funds, for a total of $15,966$ retail fund-week observations.) The institutional funds that remain active throughout the whole period of analysis are 122, for a total of $16,958$ observations. The main empirical analysis is restricted to this balanced panel.

I merge the iMoneyNet database with the CRSP Survivorship Bias Free Mutual Fund Database. CRSP data are at the quarterly level. Therefore, share classes in the two data sets are matched at that frequency. (Any within-quarter variation at the sponsor level is assumed to be constant.) To match funds in the iMoneyNet database to sponsors in the CRSP database, I proceed as follows. First, I match share classes by using the NASDAQ ticker. If a share class is matched, I assign to it a sponsor based on the entry `mgmt_cd` in the corresponding CRSP match. If `mgmt_cd` is not available, I use `mgmt_name`. If there is no match in CRSP using the NASDAQ ticker, I use the 9-digit CUSIP number. For some observations neither NASDAQ nor CUSIP have a match in the CRSP database. In those cases, I assign a match based on the other share classes in the same fund for which a match is available. (If share classes from the same fund are assigned to different sponsors in CRSP, I only use the largest share class.) If no other share class in the fund has a valid match in CRSP, I assign a match based on the other share classes in the same fund complex, as indicated by MoneyNet. (Again, if share classes from the same complex are assigned to different sponsors in CRSP, I only use the largest share class.) If no other share class in the complex has a valid match in CRSP, I match share classes by matching the name of the complex as reported by iMoneyNet with the fund name in the CRSP database. Under this algorithm, only 14 funds out of a total of 330 are not matched with a unique sponsor in CRSP. I manually match 13 of these funds with their sponsor in CRSP by using SEC filings in EDGAR, company sources, and press coverage.[45] In this way, I manage to match at least 99.26% of funds every week, corresponding to a coverage of at least 99.94% in terms of asset volume.

For each sponsor, I use CRSP data to calculate the total amount of its mutual fund assets at a given quarter and use that measure to calculate the proxy for sponsor's reputational concern as described in the main text.

Summary Statistics

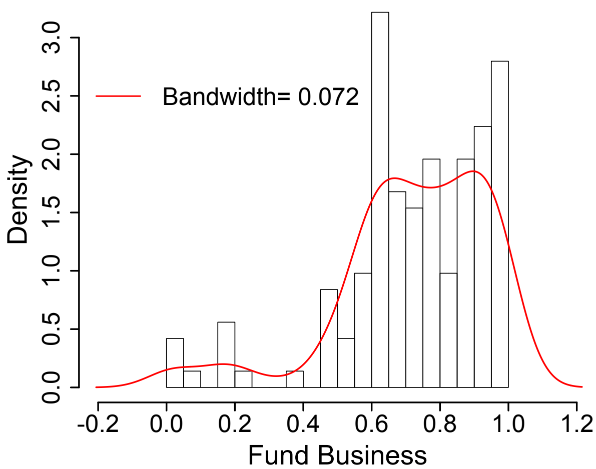
Table D.1 provides summary statistics for all institutional prime MMFs as of January 3, 2006. The sample includes 143 funds and 82 sponsors. Column (1) shows summary statistics for all funds, column (2) shows summary statistics for funds whose sponsors have *Fund Business* above the median value of 81.9% as of January 2006, and column (3) shows summary statistics for funds whose sponsors have values below the median. Results are discussed in Section 6 of the main text. My findings are close to those of KS, validating the consistency of my data set with theirs.

Distributional properties of *Fund Business*

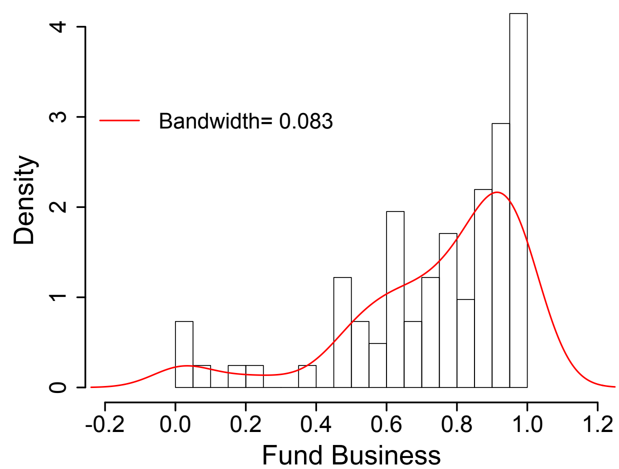
This section presents a descriptive analysis of the distributional properties of *Fund Business*. It shows that there is significant dispersion in the cross-section of sponsors' reputation concerns, which supports the validity of a "continuum-of-funds" approach and helps the identification of the effect of default cost (i.e., sponsor's reputation concerns) on the cross-sectional risk-taking differential.

[45] The only fund that I did not manage to match with the CRSP database is the Williams Capital Liquid Assets Fund, whose institutional share is WLAXX.

The left panel of Figure 6 shows the distribution of *Fund Business* in the population of funds in January 3, 2006. The distribution is widely spread on the interval $[0, 1]$, suggesting that a binary distribution would be a poor approximation of the actual one. The distribution shows some degree of multimodality with a small peak around zero (sponsors specialized in MMFs, e.g. City National Rochdale), and two pronounced peaks around 0.7 and 1 (largest asset managers, e.g PIMCO). The right panel of Figure 6 shows the distribution of *Fund Business* in the population of sponsors for the same date. Again, the distribution is widely spread on its support and shows some degree of multimodality, even though to a lesser extent. The comparison of the two distribution suggests that the some sponsors in the mid-range of *Fund Business* offer relatively more MMFs.



(a) Fund Population



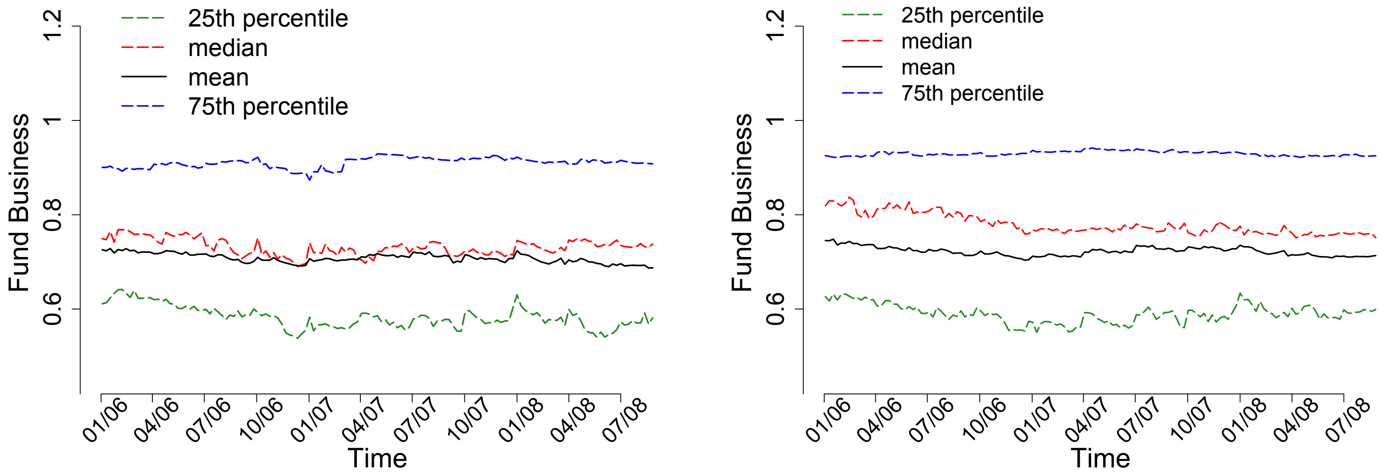
(b) Sponsor Population

Figure 6: **Distribution of *Fund Business* as of January 3, 2006.** The sample is all institutional prime MMFs (left panel), and all sponsors of institutional prime MMFs (right panel). The red line represents the density of *Fund Business* estimated using a Gaussian kernel. The bandwidth is determined according to Silverman's "rule of thumb" (Silverman, 1986, pg. 48, eqn. (3.31)).

Both at the fund level and at the sponsor level, the distribution of *Fund Business* is stable over the period of analysis. Figure 7 shows the evolution of the mean and quartiles of *Fund Business* from January 2006 to August 2008. The left panel is at the fund level, and the right panel is at the sponsor level. The results are similar.

Appendix E Risk-taking Opportunities: supplementary evidence

This section analyzes the risk-taking opportunities of prime MMFs from January, 2006 to August, 2008. The analysis is at the level of the asset classes in MMF portfolios as reported by iMoneyNet.



(a) Fund Population

(b) Sponsor Population

Figure 7: **Time Evolution of the Summary Statistics of** $Fund\ Business$**.**

This is a more granular investigation of the risk-taking opportunities of MMFs than the one in Section 6.1 and allows me to identify the riskiest asset class in the period of interest.

Since I do not directly observe the yield of the individual instruments, following KS I infer the spread of each instrument via regression

$$Spread_{i,t+1} = \alpha_i + \mu_t + \sum_j \beta_j Holdings_{i,j,t} + \gamma \cdot X_{i,t} + \varepsilon_{i,t+1} \tag{13}$$

where $Spread_{i,t+1}$ is the gross yield of fund i in week $t+1$ minus the risk-free rate (30-day T-bill weekly return), $Holdings_{i,j,t}$ denotes fund i's fractional holdings of instrument type j in week t, α_i denotes fund fixed effects, and μ_t denotes week fixed effects. The instrument types include repurchase agreements, time deposits, bank obligations (i.e., negotiable deposits), floating-rate notes, commercial papers, and asset-backed commercial papers. The omitted category is Treasuries and GSE debt. X is the set of fund-specific controls defined in (7). The coefficients of interest are β_j, which measure the return on money market instrument j in week $t+1$ relative to that of Treasuries and GSE debt. Following KS, I estimate the regression model separately for the post period from August 2007 to August 2008 and the pre period from January 2006 to July 2007. I also estimate the regression on the whole period (January 2006-August 2008).

Table E.1 shows the results. All standard errors are HAC robust. Columns (1) and (2) include only week fixed effects, while Columns (3) and (4) include both week and fund fixed effects.[46] My

[46]Including fund fixed effects alleviates the concern that funds with large holdings of risky assets might also be riskier, along other unobserved dimensions.

results are very close to those of KS. In general, all instruments, except *Bank Deposits*, have significantly larger yields in the post period. In particular, *Bank Obligations* show the largest increase in the spread relative to treasuries and GSE debt. When accounting for fund fixed effects, the yield of a fund fully invested in bank obligations would have been 94 basis points higher than the yield of a fund fully invested in Treasury and agency debt. Similar results hold for ABCP and, to a lesser extent, FRNS and CP.

Columns (5) and (6) show the results for the whole period. Qualitatively these results are similar to those for the post period. *Bank Obligations* have the largest yield, followed by ABCP, CP and FRNS. All instruments have positive and statistically significant yields relative to Treasuries and GSE debt securities.

Figure 8 shows the spread of eligible risky instruments relative to U.S. Treasuries and GSE debt from January 2006 to August 2008. I run regression (13) with two-way fixed effects for every month in the time window. Each point represents the three-month-backward MA of the coefficients on the instrument type. Before August 2007, the spread between risky instruments and U.S. Treasuries and GSE debt was at most 25 basis points, thus leaving little scope for large variations in the cross-section of funds' yields. After August 2007, the spread between risky instruments, such as bank obligations, and safe instruments, such as U.S. Treasuries, increased to 90 basis points.

In view of the results of this section, bank obligations can be regarded as the riskiest security available to MMFs in the period of analysis, consistently with KS. This justifies the definition of the main risk measure, $Holdings\ Risk$, as the percentage of assets held in bank obligations net of U.S. treasuries, GSE debt and repurchase agreements.

Appendix F Flow-performance: supplementary evidence

Table F.1 shows the results for the estimation of regression (7) using the rank of $Fund\ Flow$ ($Fund\ Flow Rank$) as dependent variable. The rank is calculated in percentiles that are normalized to $[0, 1]$ (e.g., for a fund-week in the top 98% of the distribution of fund flows, $Fund\ Flow\,Rank = 0.98$). Using the rank of fund flows is an alternative to trimming to take care of the effect of possible extreme outliers. Results are qualitatively similar to those obtained using $Fund\ Flow$ trimmed at the 0.5%. The past *Spread* is a significant determinant of the fund-flow performance only in the post period. On the other hand, the past *Spread Rank* is statistically significant both in the post and the pre period, and its economic significance is considerably larger in both periods. Moreover, when both are included, only *Spread Rank* is statistically significant.

As further robustness check, I also run regression (7) including only time fixed effects, and using trimming conditions based on the interquartile range. Results are similar and can be found in the online appendix. This additional empirical evidence confirms that the rank of performance is a better explanatory variable of money flows in the MMF industry than the raw performance and supports the choice of modeling the MMF industry as a pure tournament.

F.1 Exogeneity of the flow-performance relationship

Here I test the assumption that the flow-performance relationship can be taken as exogenous in the context of my model. Specifically, I test the hypothesis that the flow-performance relation is not explicitly affected by sponsor's reputation concerns (*Fund Business* and *Conglomerate*). This characteristic may affect the flow-performance relation if investors anticipate the effect of sponsor's reputation concern on fund's risk taking. I test this hypothesis by estimating the flow-performance relation in equation (7) with additional interactions of *Fund Business* and *Conglomerate* with *Spread Rank*. I present the results in Table F.2. Standard errors are HAC robust.

For both periods I find that the coefficients on the interaction terms are statistically and economically insignificant for both measures of reputation concern. Hence, conditional on flow performance, there is no effect of sponsor characteristics on fund flows. As first robustness check, I run the same test using *Spread* instead of *Spread Rank* as main explanatory variable, as done by KS. Results are similar and omitted for brevity. As further robustness check, I run the same test using the rank of *Fund Flow* as independent variable to alleviate the concern of outliers. Results are very similar and thus omitted for brevity.

These findings suggest that investors do not risk adjust fund performance based on sponsor characteristics and that the assumption of an exogenous flow-performance relation in the context of my model is satisfied in the data.

Appendix G MMF risk-taking: supplementary evidence

G.1 Cross-sectional risk-taking holding sponsor's concerns fixed as of 2006

Here I follow Kacperczyk and Schnabl (2013) and analyze fund risk-taking in the *Post* and *Pre* period by estimating the following regression:

$$\begin{aligned} Risk_{i,t+1} = &\alpha + \mu_t + \beta_1 Reputation\ Concerns_{i,2006} \\ &+ \beta_2 Post_t * Business\ Spillovers_{i,2006} + \gamma \cdot X_{i,2006} + \varepsilon_{i,t+1} \end{aligned} \tag{14}$$

where $Reputation\ Concerns_{i,2006}$ is a generic name for either *Fund Business* or *Conglomerate*. *Post* is an indicator variable equal to 1 for the post period and 0 for the pre period. $X_{i,2006}$ is a vector of control variables similar to those in equation (9). Both business spillover variables and other controls are measured as of January 2006, which mitigates the concern that fund risk choices are driven by changes in fund characteristics due to investment opportunity changes. Regression model (14) also includes week fixed effects (μ_t), which account for any time differences in aggregate fund flows or macroeconomic conditions. As KS, I use three measures of risk (*Risk*): *Spread*, *Holdings Risk*, and *Maturity Risk*.

To be consistent with KS (see Table IV therein), Table G.1 shows the results when both *Fund Business* and *Conglomerate* are included on the RHS of (14). Reported standard errors are HAC and cross-correlation robust. My results are qualitatively similar to those of KS. Sponsor's reputation concerns are negatively correlated with fund risk-taking in the post period, and their effect is statistically significant at the 1% level for most measures of risk. In both my regressions and those of KS, sponsor's reputation concerns tend to be negatively correlated with *Holdings Risk* also in the pre period, with the effect being statistically significant at the 1% level in my regression but insignificant in that of KS. Moreover, both in my regressions and those of KS, *Conglomerate* is negatively correlated with all measures of risk in the pre period, with its effect being statistically significant at least at the 5% level in my regressions. For robustness, I also run regression (14) using *Safe Holdings* (U.S. trasuries + GSE debt + repos) as dependent variable (see column 4). In this case, my model predicts $\beta_2 > 0$ and $\beta_1 > 0$. In the data, I find that for *Fund Business* both $\widehat{\beta}_1$ and $\widehat{\beta}_2$ are positive and statistically significant at the 1% level, in agreement with the model and empirical results of Section 6.4.

In regression (14), sponsor's reputation concern is instrumented with its value as of January 2006. While this eliminates possible endogenous correlations between sponsor's level of reputation concern and the unobserved regression error, it also excludes all truly exogenous variations in sponsor's reputation concern (e.g., shocks to the sponsor's equity mutual fund business that are orthogonal to the investment opportunities in the money market). For these reasons, in Section 6.4 I extend the analysis of KS by using as explanatory variable the lagged value of a sponsor's reputation concern.

G.2 Cross-sectional risk-taking: robustness checks

Table G.2 reports the results of regression (9) when *Fund Business* is used as main explanatory variable instead of its rank (*FB Rank*). Standard errors are HAC and cross-correlation robust. Results are very similar to those reported in Table 5 of Section 6.4, confirming the validity of my model's predictions.

As further robustness check, I also run the following instrumental variable (IV) regression model separately on the post and the pre period:

$$Risk_{i,t} = \alpha_i + \mu_t + \beta Fund\ Business_{i,t;IV:t-k} + \gamma \cdot X_{i,t-k} + \varepsilon_{i,t} \tag{15}$$

where *Risk* and X are defined as in (9), and $Fund\ Business_{i,t;IV:t-k}$ is fund i's measure of sponsor's reputation concern in week t instrumented with sponsor's reputation concern in week $t-k$. *Fund Business* is instrumented with its lagged values in order to alleviate possible endogeneity issues. For the same reason the controls X are lagged.[47] I run several regression specifications with different values of k, namely $k = 1, 4, 8$, and 12 (corresponding to 1 week, 1 month, 2 and 3 months). Table G.3 shows the results for $k = 4$ and 8. Standard errors are HAC and cross-correlation robust. The results for $k = 1$ and 12 are similar and thus omitted for brevity.

The estimation of regression (15) confirms my previous results. For both *Holdings Risk* and *Maturity Risk* the effect of (past) *Fund Business* on MMF risk-taking is negative, statistically and economically significant in both periods. Moreover, the effect in the post period tends to be stronger, with the difference being statistically significant for *Holdings Risk*. The effect of *Fund Business* on *Spread* is negative, statistically and economically significant in the post period, while it is not significant in the pre period.[48] The effect of sponsor's reputation concern on *Safe Holdings* is positive and statistically significant in the post period, and positive but not statistically significant in the pre period. These results confirm the findings of Table 5 and the predictions (1) and (3) of my model on differential risk-taking in the MMF industry. I also run regression (15) using *FB Rank* as main explanatory variable. The results are similar and omitted for brevity.

Finally, as further robustness check, I also run IV regressions in which all RHS variables in (9) are instrumented with their lagged values. The results are similar and thus omitted.

G.3 Disentangling Risk Premium from Risk Free Rate: Robustness Checks

Table G.4 shows the estimation of regression (10) when rf is the 3-month T-bill rate. The data qualitatively confirm the predictions of the model. The interaction of *FB Rank* with the risk premium is is in agreement with model's predictions, statistically significant at least at the 5% level for all measures of risk, and economically important. After an increase of 1% in the GZ excess bond premium the difference in *Holdings Risk* between funds in the lowest and highest percentile of *Fund Business* increases by roughly 6.3 percentage points, the absolute value of the difference in *Safe Holdings* increases by 3.4 percentage points, the difference in portfolio maturity by 4.2 days, and the spread differential increases by 1.8 basis points. The interaction of *FB Rank* with the rate on 3-month T-bills is in agreement with the model but never statistically significant. However, its economic effect is comparable to that of the interaction term with the risk premium. After a decrease of 1% in the 3-month T-bill rate, the difference in *Holdings Risk* between funds in the lowest and highest percentile of *Fund Business* increases by 4.4 percentage points, the absolute value of the difference in *Safe Holdings* by 2.2 percentage points, the difference in portfolio maturity by more 2.9 days, and the spread differential by 5.8 basis points.

[47] I also run a regression specification in which all time-varying and fund-varying RHS variables are instrumented with their lagged values. The results are very similar and thus omitted.

[48] When *Spread* is the dependent variable the predictive power of the "within" estimation is very small (0.3%), which means that most of the variation in spread is due to unobserved fund-specific components and time-fixed effects. Moreover, as discussed in the main text, *Spread* does not necessarily reflect active risk-taking by the fund.

Table G.5 shows the estimation of regression (10) when the risk premium $\widehat{rp}$ is proxied by *Spread Index*, defined by (6) in Section 6.1, and rf is the 30-day T-bill return. Again, the data confirm the predictions of the model: the sign of all coefficients is in agreement with the model and the coefficients of interest are statistically significant for most measures of risk. In terms of economic importance, my results suggest that the 1-month T-bill rate affects the cross-sectional risk-taking differential more than the risk premium, for both asset-class composition and maturity of fund's portfolio. However, note that *Spread Index* is an *ex post* measure of the risk premium. Hence, these results should be regarded as a qualitative robustness check of the model, not as a quantitative statement on the relative weight of risk premium and and risk-free rate on MMF risk-taking

G.4 Risk-taking in the time series: supplementary evidence

Figure 9 shows the industry average percentage of risky assets net of safe assets in fund portfolios (*Holdings Risk*), over the period 1/1/2006–12/31/2008. The 1-month T-bill rate is superimposed (green line). The industry as a whole did not significantly "reach for yield" in the second half of 2008, when the risk-free rate was falling and the risk premium increased. This is consistent with the opposite risk-taking behavior of MMFs with low and high default costs in response to increases in the premium and riskiness of the risky assets. If any, there was a more significant "reach for yield" in the pre period, when risk-free rates where relatively high and risk premia relatively low.

Table G.6 shows the results of regression (8) using the median value of *Fund Business* in the sponsor population as cutoff between "high" and "low" *Fund Business*. The risk premium is proxied by the Gilchrist and Zakrajsek (2012)'s excess bond premium for financial firms, and the risk-free rate by the 1-month T-bill return. Results are similar to those in Table 4 and qualitatively confirm the predictions of the model. When the premium and riskiness on the risky assets increase, funds with higher default costs decrease their risky investment, while funds with lower default costs tend to increase it. Holding the premium constant, both categories of funds increase their safe holdings, and for funds with lower default costs this tends to be accompanied by an extension of portfolio maturity.

As further robustness checks, I also run regression (8) using *Spread Index* as proxy for the risk premium and the 3-month T-bill rate as proxy for the risk-free rate. Results are similar and can be found in the online appendix.

				Kacperczyk & Schnabl (2013)		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	High FB	Low FB	All	High FB	Low FB
Fund Characteristics						
Spread (bp)	7.54	7.27	7.70	6.93	6.60	7.28
	(6.46)	(6.22)	(6.64)	(6.44)	(7.54)	(5.00)
Expense Ratio (bp)	35.90	34.89	36.53	31.64	32.40	30.81
	(21.79)	(22.81)	(21.23)	(19.10)	(18.43)	(19.90)
Fund Size ($mil)	6,318	4,195	7,645**	4,886	2,981	6,951***
	(10,793)	(8,413)	(11,899)	(8,685)	(4,833)	(11,169)
Maturity (days)	33.27	33.93	32.85	34.32	35.12	33.45
	(10.65)	(10.90)	(10.54)	(11.02)	(12.48)	(9.17)
Age (years)	11.20	11.12	11.25	10.61	10.43	10.81
	(6.84)	(7.36)	(6.53)	(4.75)	(5.53)	(3.75)
Family Size ($bil)	73.3	99.1	47.5*	72.8	97.5	45.9**
	(157.1)	(211.7)	(61.8)	(149.1)	(200.9)	(39.2)
Fund Business	0.745	0.929	0.562***	0.764	0.897	0.619***
	(0.248)	(0.051)	(0.230)	(0.198)	(0.064)	(0.192)
Conglomerate	0.566	0.418	0.659***	0.601	0.558	0.648
	(0.497)	(0.498)	(0.477)	(0.491)	(0.500)	(0.481)
Portfolio Holdings						
U.S. Treasuries & agency	0.059	0.065	0.055	0.060	0.072	0.048
	(0.096)	(0.092)	(0.099)	(0.109)	(0.120)	(0.095)
Repurchase Agreements	0.134	0.128	0.138	0.135	0.142	0.126
	(0.151)	(0.169)	(0.139)	(0.150)	(0.169)	(0.128)
Bank Deposits	0.034	0.016	0.045***	0.032	0.021	0.044**
	(0.058)	(0.034)	(0.067)	(0.057)	(0.039)	(0.069)
Bank Obligations	0.124	0.112	0.132	0.122	0.111	0.135
	(0.127)	(0.116)	(0.133)	(0.126)	(0.120)	(0.132)
Floating-Rate Notes	0.199	0.225	0.183	0.198	0.192	0.204
	(0.164)	(0.184)	(0.149)	(0.162)	(0.168)	(0.156)
Commercial Paper	0.314	0.305	0.319	0.320	0.356	0.280**
	(0.216)	(0.226)	(0.212)	(0.224)	(0.252)	(0.182)
Asset-Backed CP	0.136	0.149	0.128	0.134	0.106	0.164**
	(0.154)	(0.180)	(0.136)	(0.155)	(0.151)	(0.154)
Funds	143	55	88	148	77	71

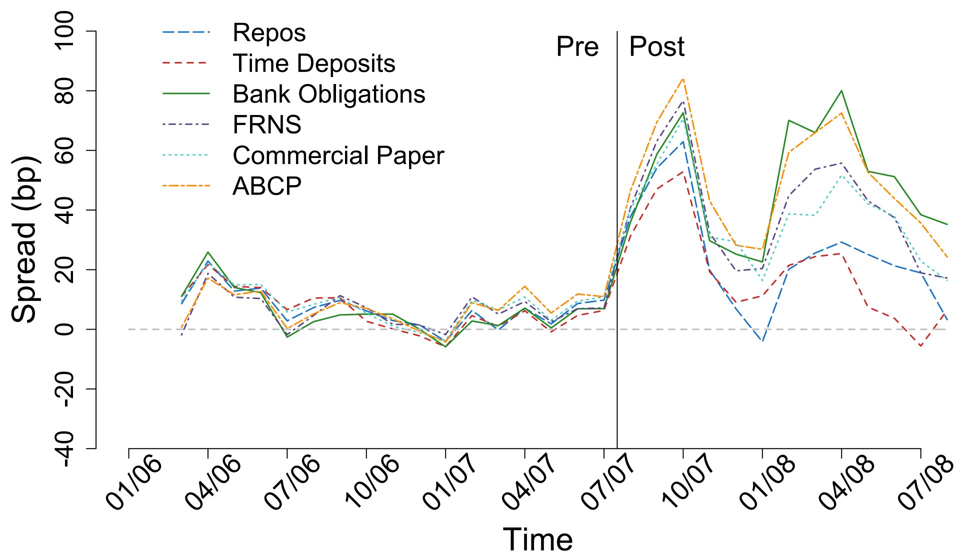
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table D.1: Summary statistics for all U.S. institutional prime MMFs as of January 3, 2006. *Fund Business* (FB) is the share of mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. High (Low) FB includes all funds with *Fund Business* above (below) the median value of *Fund Business* (81.9%). Fund characteristics are spread, expense ratio, fund size, average portfolio maturity, age, family size, and whether the fund sponsor is part of a conglomerate. Holdings are the share of assets invested in Treasuries and agency debt, repurchase agreements, bank deposits, bank obligations, floating-rate notes, commercial paper, and asset-backed commercial paper. Cross-sectional standard deviations of the given characteristics are in parentheses. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

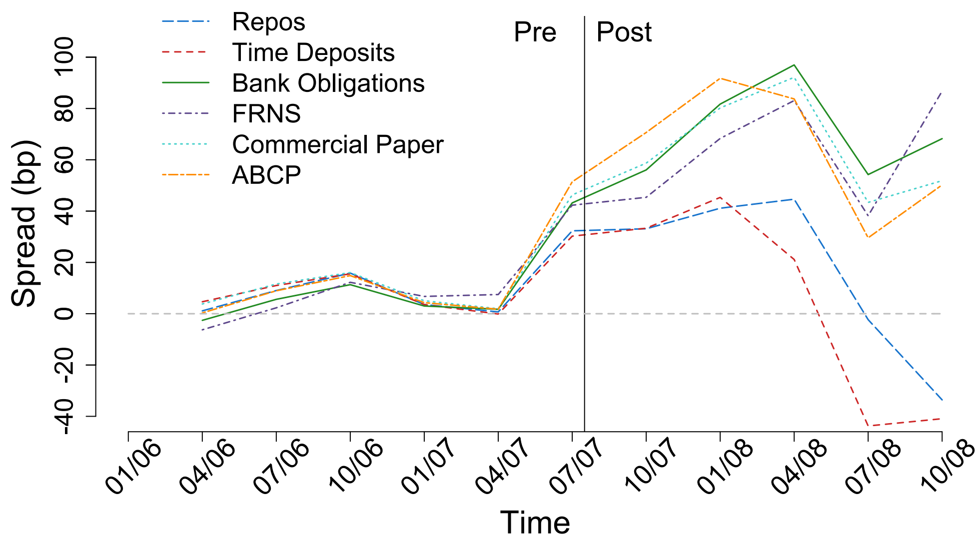
	$Spread_{i,t+1}$					
	(1)	(2)	(3)	(4)	(5)	(6)
	Post	Pre	Post	Pre	Whole Period	
Portfolio Holdings						
Repurchase Agreements$_{i,t}$	5.464	17.444***	44.292***	8.410**	17.430**	44.933***
	(11.351)	(3.536)	(14.964)	(4.072)	(8.464)	(12.508)
Bank Deposits$_{i,t}$	−7.111	16.376***	13.712	8.481**	5.601	32.814**
	(26.207)	(4.298)	(21.260)	(4.049)	(17.713)	(16.228)
Bank Obligations$_{i,t}$	78.037***	15.312***	94.000***	0.291	49.975***	68.781***
	(10.385)	(3.580)	(15.523)	(4.005)	(7.159)	(12.194)
Floating-Rate Notes$_{i,t}$	77.542***	22.005***	72.438***	5.205	51.156***	53.829***
	(8.657)	(3.484)	(17.763)	(4.448)	(6.197)	(12.758)
Commercial Paper$_{i,t}$	55.131***	16.518***	75.221***	10.494***	38.350***	53.634***
	(10.734)	(3.490)	(21.158)	(4.051)	(7.351)	(12.675)
Asset-Backed CP$_{i,t}$	74.212***	20.260***	82.188***	10.470***	47.770***	63.007***
	(11.444)	(3.480)	(17.896)	(3.972)	(7.459)	(12.247)
Fund Characteristics						
Log(Fund Size)$_{i,t}$	0.772	−0.026	4.055***	0.178	0.460	2.067
	(0.532)	(0.114)	(1.123)	(0.445)	(0.396)	(1.306)
Expense Ratio$_{i,t}$	6.133*	−0.543	31.518	8.187*	3.115	10.993
	(3.683)	(0.863)	(26.000)	(4.303)	(1.920)	(11.488)
Age$_{i,t}$	0.045	0.012	−0.292	0.169	−0.022	0.054
	(0.111)	(0.021)	(0.709)	(0.206)	(0.062)	(0.684)
Log(Family Size)$_{i,t}$	0.413	0.311***	−2.170	0.755*	0.357	0.554
	(0.547)	(0.118)	(2.464)	(0.431)	(0.313)	(0.927)
Week fixed effect	Y	Y	Y	Y	Y	Y
Fund fixed effect	N	N	Y	Y	N	Y
Observations	7,602	11,599	7,602	11,599	19,335	19,335
Adj. R^2 (within)	0.51	0.25	0.18	0.04	0.29	0.11
R^2 (overlall)	0.95	0.97	0.97	0.98	0.97	0.98

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table E.1: **Investment opportunities at the security-class level.** The sample is all U.S. institutional prime money market funds. The dependent variable *Spread* is computed as the annualized fund yield minus the Treasury bill rate. Holdings variables are the share of assets invested in repurchase agreements, bank deposits, bank obligations, floating-rate notes, commercial paper (CP), and asset-backed CP (omitted category is U.S. Treasury and GSE debt). Fund characteristics are logarithm of fund size, expense ratio, fund age, and logarithm of fund family size. All regressions are at the weekly level and include week fixed effects. Columns (3) and (4) include also fund fixed effects. Columns (1) and (3) cover the period 8/1/2007-8/31/2008 (post period). Columns (2) and (4) cover the period 1/1/2006-7/31/2007 (pre period). Standard errors are HAC-robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.



(a) Monthly



(b) Quarterly

Figure 8: **Spread by instrument type.** I implement the panel regression model in Table E.1 with two-way fixed effects over the period from January 2006 to August 2008. In the top chart (a), I estimate the regression model every month: each point represents the three-month-backward MA of coefficients on the instrument type. In the bottom chart (b), I estimate the regression model every quarter: each point represents the two-quarter-backward MA of coefficients on the instrument type. Each point represents the return relative to the omitted category (Treasuries and GSE debt) measured in basis points.

	Fund Flow Rank$_{i,t+1}$					
	(1)	(2)	(3)	(4)	(5)	(6)
	Post	Pre	Post	Pre	Post	Pre
$Spread\ Rank_{i,t}$			0.118***	0.026*	0.078*	0.049**
			(0.022)	(0.015)	(0.043)	(0.025)
$Spread_{i,t}$	0.002***	0.001			0.001	−0.002
	(0.000)	(0.001)			(0.001)	(0.002)
$Log(Fund\ Size)_{i,t}$	−0.255***	−0.214***	−0.256***	−0.215***	−0.257***	−0.215***
	(0.062)	(0.034)	(0.067)	(0.034)	(0.065)	(0.034)
$Expense\ Ratio_{i,t}$	0.077	−0.108	0.132	−0.111	0.104	−0.096
	(0.155)	(0.172)	(0.166)	(0.171)	(0.162)	(0.172)
$Age_{i,t}$	−0.003	−0.028**	−0.005	−0.028**	−0.004	−0.028**
	(0.007)	(0.012)	(0.007)	(0.012)	(0.007)	(0.012)
$Flow\ Volatility_{i,t}$	−0.004***	0.082	−0.002***	0.079	−0.003***	0.077
	(0.001)	(0.062)	(0.000)	(0.062)	(0.001)	(0.063)
$Log(Family\ Size)_{i,t}$	0.044	0.002	0.042	0.002	0.043	0.003
	(0.027)	(0.011)	(0.028)	(0.010)	(0.027)	(0.011)
Week fixed effect	Y	Y	Y	Y	Y	Y
Fund fixed effect	Y	Y	Y	Y	Y	Y
Observations	7,496	9,625	7,496	9,625	7,496	9,625
Adj. R^2 (within)	0.024	0.020	0.025	0.021	0.025	0.021
R^2 (overall)	0.050	0.043	0.050	0.043	0.050	0.044

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table F.1: **Flow-performance relation: performance rank matters more than raw performance.** Columns (1), (3) and (5) cover the period 8/1/2007-8/31/2008 (*post* period). Columns (2), (4) and (6) cover the period 1/1/2006-7/31/2007 (*pre* period). The dependent variable is *Fund Flow Rank*, which is the rank of *Fund Flow*. *Fund Flow* is the percentage change in total net assets from week t to week $t+1$, adjusted for earned interests. The rank is computed in percentiles normalized to $[0,1]$. Using the rank of *Fund Flow* alleviates the concern of outliers in the distribution of fund flows. Independent variables are the weekly annualized spread from $t-1$ to t, its rank in percentiles normalized to $[0,1]$, logarithm of fund size, fund expense ratio, fund age, volatility of fund flows based on past 12-week fund flows, and logarithm of fund family size. All regressions are at the weekly level and include fund and week fixed effects. Standard errors are HAC robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

	$Fund\ Flow_{i,t+1}$					
	(1)	(2)	(3)	(4)	(5)	(6)
	Post	Pre	Post	Pre	Post	Pre
$Spread\ Rank_{i,t}$	3.229***	1.339**	2.156***	0.618*	3.617***	1.368*
	(1.039)	(0.676)	(0.494)	(0.367)	(1.179)	(0.814)
$Fund\ Business_{i,t}*$	−0.019	−0.010			−0.020	−0.010
$Spread\ Rank_{i,t}$	(0.014)	(0.009)			(0.014)	(0.009)
$Conglomerate_{i,t}*$			−0.004	0.001	−0.005	0.000
$Spread\ Rank_{i,t}$			(0.006)	(0.005)	(0.007)	(0.006)
$Log(Fund\ Size)_{i,t}$	−5.656***	−4.229***	−5.578***	−4.182***	−5.664***	−4.230***
	(0.938)	(0.681)	(0.647)	(0.442)	(0.938)	(0.679)
$Expense\ Ratio_{i,t}$	1.114	−1.168	0.714	−1.237	1.333	−1.169
	(2.491)	(3.339)	(2.721)	(1.679)	(2.508)	(3.340)
$Age_{i,t}$	−0.137	−0.488**	−0.138	−0.497***	−0.136	−0.489**
	(0.135)	(0.233)	(0.131)	(0.112)	(0.137)	(0.233)
$Flow\ Volatility_{i,t}$	−0.018***	2.849**	−0.016***	2.850**	−0.020***	2.844**
	(0.005)	(1.391)	(0.006)	(1.289)	(0.005)	(1.392)
$Log(Family\ Size)_{i,t}$	0.952**	0.072	0.846**	−0.003	0.964**	0.073
	(0.427)	(0.205)	(0.378)	(0.186)	(0.425)	(0.208)
Week fixed effect	Y	Y	Y	Y	Y	Y
Fund fixed effect	Y	Y	Y	Y	Y	Y
Observations	7,387	9,467	7,387	9,467	7,387	9,467
Adj. R^2 (within)	0.032	0.024	0.032	0.024	0.032	0.024
R^2 (overlall)	0.081	0.061	0.080	0.061	0.081	0.061

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table F.2: **Flow-performance relation: no explicit effect of sponsor's reputation concerns.** Columns (1), (3) and (5) cover the period 8/1/2007-8/31/2008 (*post* period). Columns (2), (4) and (6) cover the period 1/1/2006-7/31/2007 (*pre* period). The dependent variable is *Fund Flow*, computed as the percentage change in total net assets from week t to week $t+1$, adjusted for earned interests and trimmed at the 0.5%. Independent variables are the weekly spread rank from $t-1$ to t, logarithm of fund size, fund expense ratio, fund age, volatility of fund flows based on past 12-week flows, and logarithm of fund family size. Additional independent variables are the interactions of *Spread Rank* with *Fund Business* and *Conglomerate*. *Fund Business* is the share of mutual fund assets other than institutional prime MMF in sponsor's total mutual fund assets. *Conglomerate* is an indicator variable equal to 1 if the fund sponsor is affiliated with a financial conglomerate and 0 otherwise. All regressions are at the weekly level and include week and fund fixed effects. Standard errors are HAC robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

	$Holdings\ Risk_{i,t+1}$	$Maturity\ Risk_{i,t+1}$	$Spread_{i,t+1}$	$Safe\ Holdings_{i,t+1}$
	(1)	(2)	(3)	(4)
$Fund\ Business_{i,2006} * Post_t$	-14.828^{***}	-12.071^{***}	-9.862^{***}	7.899^{***}
	(1.707)	(1.153)	(1.533)	(1.173)
$Conglomerate_{i,2006} * Post_t$	-2.393^{***}	0.725	-5.296^{***}	2.530^{***}
	(0.425)	(0.500)	(0.490)	(0.387)
$Fund\ Business_{i,2006}$	-11.007^{***}	6.725^{***}	−0.266	3.051^{***}
	(1.120)	(0.747)	(0.239)	(0.933)
$Conglomerate_{i,2006}$	-2.728^{***}	-0.830^{**}	-1.983^{***}	0.032
	(0.228)	(0.336)	(0.160)	(0.150)
$Controls_{i,2006}$	Y	Y	Y	Y
$Controls_{i,2006} * Post_t$	Y	Y	Y	Y
Week fixed effect	Y	Y	Y	Y
Fund fixed effect	N	N	N	N
Observations	16,836	16,836	16,836	16,836
R^2 (overall)	0.181	0.121	0.977	0.114

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table G.1: **Cross-sectional risk-taking differential in the *Pre* and *Post* period.** The sample is all U.S. institutional prime money market funds for the period from 1/1/2006 to 8/31/2008. The dependent variables are: the percentage of risky assets (bank obligations) net of safe assets (US treasuries, GSE debt, and repos) in a fund's portfolio (*Holdings Risk*) in column (1), average portfolio maturity (*Maturity Risk*) in column (2), the weekly annualized fund spread (*Spread*) in column (3), and the percentage of safe assets in a fund's portfolio (*Safe Holdings*) in columns (4). *Fund Business* is the share of mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. *Conglomerate* is an indicator variable equal to 1 if the fund sponsor is affiliated with a financial conglomerate, and 0 otherwise. *Post* is an indicator variable equal to 1 for the period from 8/1/2007 to 8/31/2008, and 0 otherwise. The other independent variables (*Controls*) are fund assets, expense ratio, fund age, and fund family size as of 1/3/2006. All regressions are at the weekly level and include week fixed effects. Standard errors are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

	$Holdings\ Risk_{i,t}$		$Maturity\ Risk_{i,t}$		$Spread_{i,t}$		$Safe\ Holdings_{i,t}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	k=4	k=8	k=4	k=8	k=4	k=8	k=4	k=8
$Fund\ Business_{i,t-k}$	−20.891***	−19.473***	−9.238***	−8.217***	−3.019	−3.422	6.278***	4.357*
	(3.438)	(3.337)	(2.118)	(2.174)	(3.590)	(3.231)	(2.425)	(2.598)
$Fund\ Business_{i,t-k} * Post_t$	−11.037***	−10.247***	−7.728***	−7.763***	−3.237***	−3.522***	8.106***	7.510***
	(1.528)	(3.174)	(0.937)	(1.955)	(0.711)	(3.209)	(1.265)	(2.469)
$Controls_{i,t-k}$	Y	Y	Y	Y	Y	Y	Y	Y
$Controls_{i,t-k} * Post_t$	Y	Y	Y	Y	Y	Y	Y	Y
Week Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Fund Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Observations	16,470	15,982	16,470	15,982	16,470	15,982	16,470	15,982
Adj. R^2 (within)	0.037	0.034	0.042	0.039	0.035	0.031	0.029	0.026
R^2 (overall)	0.761	0.763	0.585	0.589	0.982	0.983	0.757	0.759

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table G.2: **Cross-sectional risk-taking differential in the** ***Pre*** **and** ***Post*** **period.** The sample is all U.S. institutional prime money market funds continuously active throughout the period from 1/1/2006 to 8/31/2008. The dependent variables are: the percentage of risky assets (bank obligations) net of safe assets (US treasuries, GSE debt, and repos) in a fund's portfolio ($Holdings\ Risk$) in columns (1)–(2), average portfolio maturity ($Maturity\ Risk$) in columns (3)–(4), the weekly annualized fund spread ($Spread$) in column (5)–(6), and the percentage of safe assets in a fund's portfolio ($Safe\ Holdings$) in columns (7)–(8). $Fund\ Business$ is the share of mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. $Post$ is an indicator variable equal to 1 for the period from 8/1/2007 to 8/31/2008, and 0 otherwise. The other independent variables ($Controls$) are fund assets, expense ratio, fund age, and fund family size. All regressions are at the weekly level and include week and fund fixed effects. Standard errors are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

	$Holdings\ Risk_{i,t}$		$Maturity\ Risk_{i,t}$		$Spread_{i,t}$		$Safe\ Holdings_{i,t}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Post	Pre	Post	Pre	Post	Pre	Post	Pre
				$k = 4$				
$Fund\ Business_{i,t}$(IV: $t-k$)	-54.030^{***}	-13.159^{***}	-14.867^{***}	-8.856^{**}	-42.688^{***}	3.107	34.512^{***}	2.182
	(12.639)	(4.271)	(5.523)	(3.821)	(7.558)	(2.126)	(8.220)	(2.432)
F-statistics (1st stage IV)	$3.1 \cdot 10^5$	$5.3 \cdot 10^5$	$3.1 \cdot 10^5$	$5.3 \cdot 10^5$	$3.1 \cdot 10^5$	$5.3 \cdot 10^5$	$3.1 \cdot 10^5$	$5.3 \cdot 10^5$
Adj. R^2 (within)	0.018	0.018	0.009	0.011	0.015	0.003	0.023	0.009
R^2 (overall)	0.841	0.823	0.713	0.648	0.974	0.981	0.830	0.824
Observations	6,344	9,638	6,344	9,638	6,344	9,638	6,344	9,638
				$k = 8$				
$Fund\ Business_{i,t}$(IV: $t-k$)	-69.894^{***}	-21.432^{***}	-14.678^{**}	-18.326^{***}	-62.555^{***}	3.674^{*}	37.269^{***}	1.968
	(10.371)	(5.818)	(6.009)	(5.292)	(13.078)	(2.156)	(5.538)	(2.524)
F-statistics (1st stage IV)	$1.7 \cdot 10^5$	$2.9 \cdot 10^5$	$1.7 \cdot 10^5$	$2.9 \cdot 10^5$	$1.7 \cdot 10^5$	$2.9 \cdot 10^5$	$1.7 \cdot 10^5$	$2.9 \cdot 10^5$
Adj. R^2 (within)	0.028	0.017	0.011	0.009	0.007	0.001	0.032	0.011
R^2 (overall)	0.850	0.827	0.734	0.655	0.977	0.982	0.842	0.831
Observations	5,856	9,150	5,856	9,150	5,856	9,150	5,856	9,150
$Controls_{i,t-k}$	Y	Y	Y	Y	Y	Y	Y	Y
Week Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Fund Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table G.3: **Cross-sectional risk-taking differential in the *Pre* and *Post* Period: separate regressions.** The sample is all U.S. institutional prime money market funds continuously active throughout the period from 1/1/2006 to 8/31/2008. The dependent variables are: the percentage of risky assets (bank obligations) net of safe assets (US treasuries, GSE debt, and repos) in a fund's portfolio (*Holdings Risk*) in columns (1)–(2), average portfolio maturity (*Maturity Risk*) in columns (3)–(4), the weekly annualized fund spread (*Spread*) in column (5)–(6), and the percentage of safe assets in a fund's portfolio (*Safe Holdings*) in columns (7)–(8). *Fund Business* is the share of mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. *Fund Business* in week t is instrumented with its lagged value from week $t-k$ ($k = 4$ or $k = 8$). The other independent variables (*Controls*) are fund assets, expense ratio, fund age, and fund family size. All regressions are at the weekly level and include week and fund fixed effects. Standard errors are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

	(1) *Holdings Risk*	(2) *Safe Holdings*	(3) *Holdings Risk*	(4) *Safe Holdings*	(5) *Holdings Risk*	(6) *Safe Holdings*
$FB\,Rank_{i,t-1} * \widehat{rp}_t$	-6.865^{***}	3.688^{***}			-6.298^{***}	3.411^{***}
	(1.019)	(0.787)			(1.351)	(1.084)
$FB\,Rank_{i,t-1} * rf_t$			28.287^{***}	-15.088^{***}	4.444	−2.177
			(6.702)	(3.851)	(4.619)	(4.240)
Adj. R^2 (within)	0.038	0.023	0.031	0.019	0.038	0.023
R^2 (overall)	0.785	0.787	0.783	0.786	0.785	0.787
	Maturity Risk	*Spread*	*Maturity Risk*	*Spread*	*Maturity Risk*	*Spread*
$FB\,Rank_{i,t-1} * \widehat{rp}_t$	-4.568^{***}	-2.568^{***}			-4.201^{***}	-1.828^{**}
	(0.993)	(0.731)			(1.181)	(0.917)
$FB\,Rank_{i,t-1} * rf_t$			18.779^{***}	12.724^{***}	2.874	5.803
			(4.305)	(4.063)	(4.609)	(5.674)
Adj. R^2 (within)	0.039	0.034	0.031	0.034	0.039	0.036
R^2 (overall)	0.619	0.984	0.616	0.984	0.619	0.984
$Controls_{i,t-k}$	Y	Y	Y	Y	Y	Y
Month Fixed Effects	Y	Y	Y	Y	Y	Y
Fund Fixed Effects	Y	Y	Y	Y	Y	Y
Observations	3,782	3,782	3,782	3,782	3,782	3,782

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table G.4: **Cross-sectional risk-taking differential: risk-free rate vs. risk premium.** $\widehat{rp}$ is the excess bond premium for financial firms from Gilchrist and Zakrajsek (2012). rf_t is the return on 3-month T-bills. The sample is all U.S. institutional prime money market funds continuously active throughout the period from 1/1/2006 to 8/31/2008 ($n = 122$). Data are at the monthly level ($T = 31$). In the top panel, the dependent variables are: the percentage of risky assets (bank obligations) net of safe assets (US treasuries, GSE debt, and repos) in a fund's portfolio (*Holdings Risk*) in columns (1), (3), and (5), and the percentage of safe assets in a fund's portfolio (*Safe Holdings*) in columns (2), (4), and (6). In the bottom panel, the dependent variables are: average portfolio maturity (*Maturity Risk*) in columns (1), (3), and (5), the weekly annualized fund spread (*Spread*) in column (2), (4), (6). *FB Rank* is the rank in percentiles normalized to $[0, 1]$ of *Fund Business*, which is the share of mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. The other independent variables (*Controls*) are fund assets, expense ratio, fund age, fund family size, and lagged *FB Rank*. All regressions include month and fund fixed effects. Standard errors are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Holdings Risk	*Safe Holdings*	*Holdings Risk*	*Safe Holdings*	*Holdings Risk*	*Safe Holdings*
$FB\,Rank_{i,t-1} * \widehat{rp}_t$	-6.176^{***}	3.226^{***}			-2.638^{*}	1.346
	(1.852)	(1.145)			(1.525)	(1.232)
$FB\,Rank_{i,t-1} * rf_t$			38.501^{***}	-20.285^{***}	30.343^{***}	-16.123^{***}
			(7.562)	(4.692)	(7.799)	(5.356)
Adj. R^2 (within)	0.042	0.024	0.046	0.026	0.047	0.026
R^2 (overall)	0.786	0.787	0.787	0.788	0.787	0.788
	Maturity Risk	*Spread*	*Maturity Risk*	*Spread*	*Maturity Risk*	*Spread*
$FB\,Rank_{i,t-1} * \widehat{rp}_t$	-5.095^{***}	-2.101^{***}			-2.606^{***}	-0.138
	(1.123)	(0.576)			(0.730)	(0.937)
$FB\,Rank_{i,t-1} * rf_t$			29.404^{***}	17.262^{***}	21.347^{***}	16.835^{***}
			(4.272)	(3.477)	(3.773)	(5.170)
Adj. R^2 (within)	0.029	0.009	0.033	0.011	0.035	0.011
R^2 (overall)	0.616	0.983	0.617	0.983	0.618	0.983
$Controls_{i,t-k}$	Y	Y	Y	Y	Y	Y
Month Fixed Effects	Y	Y	Y	Y	Y	Y
Fund Fixed Effects	Y	Y	Y	Y	Y	Y
Observations	3,782	3,782	3,782	3,782	3,782	3,782

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table G.5: **Cross-sectional risk-taking differential: risk-free rate vs. risk premium.** $\widehat{rp}$ is *Spread Index*, the index of spreads on typical risky securities available to MMFs defined by (6) in the main text. rf_t is the return on 30-day T-bills. The sample is all U.S. institutional prime money market funds continuously active throughout the period from 1/1/2006 to 8/31/2008 ($n = 122$). Data are at the monthly level ($T = 31$). In the top panel, the dependent variables are: the percentage of risky assets (bank obligations) net of safe assets (US treasuries, GSE debt, and repos) in a fund's portfolio (*Holdings Risk*) in columns (1), (3), and (5), and the percentage of safe assets in a fund's portfolio (*Safe Holdings*) in columns (2), (4), and (6). In the bottom panel, the dependent variables are: average portfolio maturity (*Maturity Risk*) in columns (1), (3), and (5), the weekly annualized fund spread (*Spread*) in column (2), (4), (6). *FB Rank* is the rank in percentiles normalized to $[0, 1]$ of *Fund Business*, which is the share of sponsor's mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. The other independent variables (*Controls*) are fund assets, expense ratio, fund age, fund family size, and lagged *FB Rank*. All regressions include month and fund fixed effects. Standard errors are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.

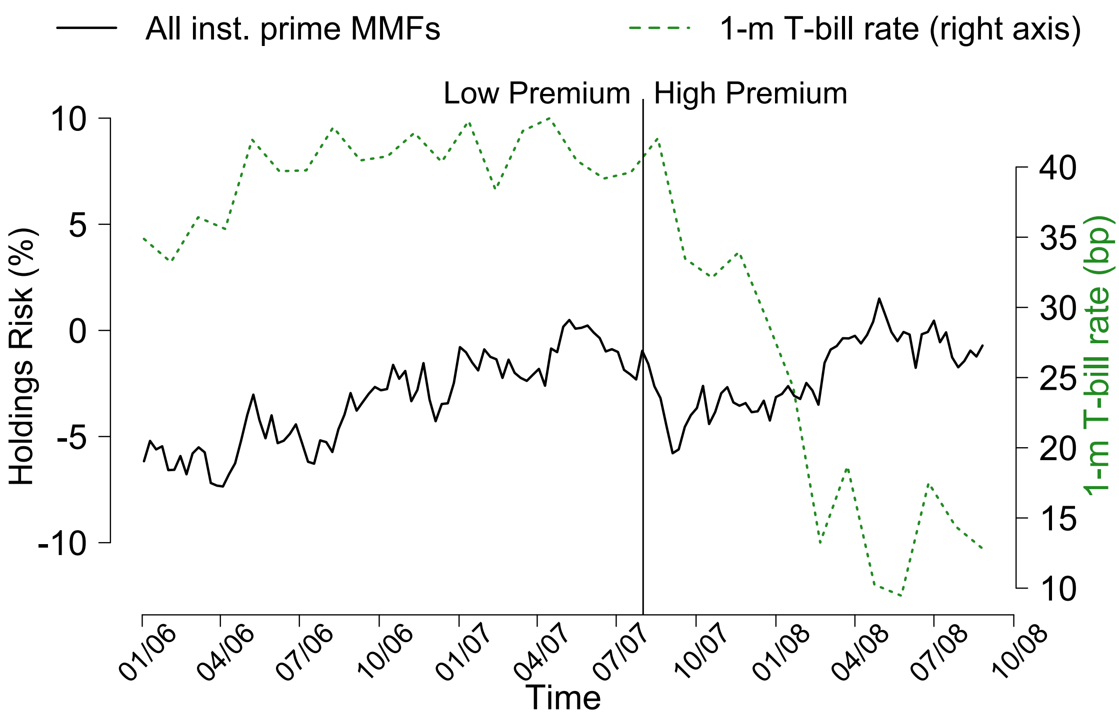


Figure 9: **Industry average** ***Holdings Risk*****.** The black line represents the industry average percentage of assets held in bank obligations (risky assets) net of U.S. trasuries, GSE debt, and repurchase agreements (safe assets). The green line represents the weekly return on 1-month T-bills (from CRSP). The scale for average holdings is on the left y-axis. The scale for the T-bill rate is on the right y-axis.

	(1)	(2)	(3)
	$Holding\, Risk$	$Maturity\, Risk$	$Safe\, Holdings$
$High\, FB_{i,t-1} * \widehat{rp}_t$	-3.636^{***}	-1.627^{**}	2.531^{***}
	(0.671)	(0.680)	(0.512)
$Low\, FB_{i,t-1} * \widehat{rp}_t$	1.922^{**}	0.297	-0.311
	(0.878)	(0.669)	(0.840)
$High\, FB_{i,t-1} * rf_t$	-0.444	-5.357	-9.397^{**}
	(4.362)	(3.789)	(4.281)
$Low\, FB_{i,t-1} * rf_t$	2.507	-8.558^{**}	-9.843^{*}
	(5.258)	(4.230)	(5.324)
$Controls_{i,t-1}$	Y	Y	Y
Fund Fixed Effects	Y	Y	Y
Adj. R^2 (within)	0.073	0.085	0.058
R^2 (overall)	0.759	0.568	0.755
Observations	3,782	3,782	3,782

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table G.6: **Reach for yield: risk premium vs. risk-free rate. Cutoff high vs. low default costs: median reputation concern in sponsor population.** The sample is all U.S. institutional prime money market funds continuously active throughout the period from 1/1/2006 to 8/31/2008 ($n = 122$). Data are at the monthly level ($T = 31$). The dependent variables are: the percentage of risky assets (bank obligations) net of safe assets (US treasuries, GSE debt, and repos) in a fund's portfolio ($Holdings\ Risk$) in column (1), average portfolio maturity ($Maturity\ Risk$) in column (2), and the percentage of safe assets in a fund's portfolio ($Safe\ Holdings$) in column (3). The risk premium $\widehat{rp}$ is the excess bond premium for financial firms from Gilchrist and Zakrajsek (2012). The risk-free rate rf_t is the return on 30-day T-bills. *Low* (*High*) $FB_{i,t}$ is a binary variable equal to 1 if fund i's $Fund\, Business$ is below (above) the median value in the sponsor population in month t, and 0 otherwise. *Fund Business* is the share of mutual fund assets other than institutional prime money market funds in sponsor's total mutual fund assets. Other independent variables ($Controls$) are fund assets, expense ratio, fund age, fund family size, and $Fund\ Business$. All regressions include fund fixed effects. Standard errors are HAC and cross-correlation robust. ***, **, * represent 1%, 5%, and 10% statistical significance, respectively.