Reputation Concerns and Slow-Moving Capital[1]

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Abstract

This paper analyzes fund managers' reputation concerns in a dynamic equilibrium model. It offers a unified explanation for a number of seemingly unrelated phenomena. The model explains why many popular hedge fund trading strategies have negatively skewed distributions. It also offers an explanation for the documented phenomenon that capital sometimes appears to be slow moving, leaving attractive investment opportunities unexploited, yet other times appears capricious, flying quickly from one strategy to another and leading to large capital relocation and price fluctuations without any news about the fundamentals. More broadly, the model sheds light on how the popularity of trading strategies evolves over time and on their consequences for market prices.

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1 Introduction

The phenomenon of slow-moving capital has recently attracted substantial attention. For example, Duffie (2010) summarizes a large body of empirical literature that documents the price impact of demand or supply shocks in various financial markets. Capital mobility often seems limited in response to these shocks, and Duffie devotes his presidential address to an asset pricing model in which some investors' absence from the market slows the market's response to shocks.

How slowly does the market respond to shocks? Mitchell, Pedersen, and Pulvino (2007) document cases in which capital appears unresponsive to profitable opportunities even after many quarters. What causes this surprisingly long delay? During such a long period of time, what prevents investors in the relevant markets from raising more capital? The answer to these questions, which lies outside the model in Duffie (2010) where investors' absence is taken as exogenous, is the focus of our paper.

Foreshadowing our main idea, it is interesting to note the common precursor to the slow-moving capital cases in Mitchell, Pedersen, and Pulvino (2007): The underlying strategies in these cases tend to be highly popular among money managers until the arrival of big shocks, which lead to large losses and drastic capital withdrawal. Only after the shocks does capital suddenly become slow moving–i.e., reluctant to reenter the strategies. Those drastic losses and the ensuing capital withdrawal have received relatively less attention, but they inform the main idea in our paper, which attempts to shed light on the following questions: Why does capital sometimes appear to be extremely slow moving, yet other times appear to be capricious and fast-moving? More generally, how does the popularity of strategies evolve over time? What are the consequences of this evolution?

We argue that these questions can be better understood in the context of fund managers' reputation concerns. Put simply, when a big negative shock hits a certain trading strategy, the money managers in that strategy suffer large losses. This damages those managers' reputations, leading to large capital withdrawal and further amplifying the original shock. Now, this trading strategy becomes even more profitable than it was before the shock, but it has a hard time attracting capital. The reason is that the managers who have the expertise to implement this strategy have

damaged reputations and become more cautious in reentering this strategy because any further losses may cost their careers. The delay for capital to reenter can be substantial if rebuilding reputation is a slow process.

There can be many reasons why it takes a long time for a manager to rebuild his reputation. In this paper, we only explicitly model one. Intuitively, if a manager's reputation is "right on the verge" (i.e., any further missteps will cost his career), he would be attracted to strategies with small probabilities to incur losses and give up more profitable opportunities if they have a higher chance of incurring temporary losses. In fact, many popular hedge fund strategies have been compared to "picking up nickels in front of a steamroller" because they appear to earn small positive returns most of the time but occasionally lead to dramatic losses.[1] Managers' "picking up nickels" has a natural but subtle consequence: Their reputation tends to go up gradually, in small steps, but occasionally drops sharply in a big step, since they tend to make small profits most of the time but incur big losses occasionally. Put differently, by the law of the iterated expectations, a manager's reputation (i.e., investors' expectation of their manager's ability) follows a martingale. Obviously, if a martingale process goes up more often than down, the size of the up-move has to be smaller than the size of the down-move.

We formalize these notions in a simple dynamic model: Investors do not have access to investment opportunities but can delegate their capital to managers, who choose among investment strategies. After the investment return is realized, investors update their belief about the managers' ability based on their performance. We assume that investors are sophisticated enough to find out which strategy was implemented ex post and rationally update their belief. Managers are rewarded based on their performance according to an exogenous compensation contract. The key ingredient of our model is that a manager will be fired once his reputation (i.e., investors' perception of his ability) falls below a certain threshold and that being fired is costly to a manager.[2] Despite its

[1] One example is the currency carry trade, where speculators borrow currencies with low interest rates to purchase currencies with high interest rates. Brunnermeier, Nagel, and Pedersen (2008) document that the return distributions for typical carry trade strategies are negatively skewed. Plantin and Shin (2008) provide a model in which the equilibrium exchange rate dynamics lead to a negatively skewed return distribution for carry trades.

[2] For example, Brown, Goetzmann, and Park (2001) find that a series of lackluster returns tends to lead to the termination of a hedge fund manager and that once a manager is fired, it is hard for him to restart his career as a manager.

simple structure, the model delivers a rich set of implications.

First, the model shows that because of reputation concerns, managers may prefer nickel-picking strategies even when they offer lower expected returns. Intuitively, if a manager chooses alternative strategies, which offer higher expected returns but also higher likelihood for losses, then he is likely to incur some losses before reaping the expected profit. In the meantime, as his reputation suffers following each loss, the manager faces the risk of being fired before the profits arrive. To the extent that the manager is concerned about this risk, he may choose the nickel-picking strategy even if it offers a lower expected return.[3] We document some systematic evidence consistent with this implication.

Second, reputation concerns have a stronger impact on managers with modest reputations than on those with very high reputations. The intuition is that a modest-reputation manager's job is not secure, leading to a strong incentive to adjust his strategy in order to keep his job safe. This concern is naturally much weaker for a high-reputation manager. As a result, due to reputation concerns alone, managers with different reputations may prefer to invest in different strategies.

This intuition highlights the third and most important insight from our model: Managers' reputation levels fluctuate over time, leading to time variation in popularity among various strategies. Imagine managers invest in the strategy they find most appealing. Upon the arrival of a big shock on that popular strategy, managers' performance and reputation both suffer. At the lower reputation level, the original popular strategy may become unappealing, leading to sudden and drastic capital withdrawal. The managers with damaged reputations would stay away from this strategy, which may make it even more profitable than before. Moreover, as explained earlier, it may take a long time for those managers to rebuild their reputation, leaving the profitable opportunity unexploited for an extended period of time.

These results fit nicely with the empirical evidence documented in Mitchell, Pedersen, and

[3]For example, the high-profile winners in the recent crisis, who fought the housing bubble using credit default swaps (CDS) and suffered repeated losses until the bubble eventually burst, were generally those investors with fewer reputation concerns who either implemented the strategy with personal wealth ("Tiger's Julian Robertson roars again," *CNNMoney.com*, January 29, 2008; "In Beverly Hills, A Meltdown Mogul Is Living Large," *Wall Street Journal*, January 15, 2008) or made an extra effort to convince their investors to stay the course ("Trader Made Billions on Subprime," *Wall Street Journal*, January 15, 2008.)

Pulvino (2007): Before the end of 2004, convertible bond arbitrage funds were quite popular and collectively managed around $40 billion of assets. After a series of disappointing returns, however, this strategy quickly ran out of fashion in 2005 and the total assets under management fell by half. Interestingly, the authors also note that the typical convertible bond arbitrage strategy appeared to be *more* profitable in 2005 and this seemingly profitable opportunity appeared to last until the end of their sample, well into 2006.

Our model provides an additional testable implication. In the context of the convertible bond arbitrage case, our analysis suggests that poor performance from convertible bond arbitrage funds should lead to larger outflows during 2005 and 2006, when those managers reputations are damaged, than comparably poor performance before 2004. More generally, our model implies that once a large amount of capital has fled from a strategy, the expected return of this strategy tends to become higher for an extended period of time, during which poor performance in this strategy tends to generate larger-than-usual capital outflows.

Our paper complements the recent literature that tries to understand slow-moving capital. For example, Duffie (2010) explores the consequences of the fact that some investors are absent from the market. He and Xiong (2009) argue that the optimal contract choice can restrict the movement of capital. Acharya, Shin, and Yorulmazer (2009) show that the tradeoff between making investments today and waiting for arbitrage opportunities in the future can lead to a shortage of capital when occasional fire sales occur. Oehmke (2009) argues that one cannot raise capital quickly if he has to sell assets in another illiquid market. While the mechanisms in these studies are likely to have contributed to the slow-moving capital phenomenon, our paper is the only one that also attempts to explain its precursor: the drastic capital relocation due to poor performance. Moreover, the mechanism in our paper is likely to be more suitable for cases in which capital appears to be extremely slow moving.

Our paper belongs to the growing literature that focuses on the impact of managers' reputation concerns (e.g., Allen and Gorton (1993), Dow and Gorton (1997), Stein (2005), Dasgupta and Prat (2006, 2008) and Dasgupta, Prat, and Verardo (2007), Vayanos and Woolley (2008) and Guerrieri and Kondor (2008)) and the literature on limits to arbitrage (Dow and Gorton (1994), Shleifer

and Vishny (1997)). More broadly, our paper is also related to the literature on delegated asset management on portfolio choices (e.g., Carpenter (2000), Ross (2004), Basak, Shapiro, and Tepla (2006), Basak, Pavlova, and Shapiro (2007), Basak and Makarov (2008)) and on equilibrium prices (e.g., Cuoco and Kaniel (2001), Vayanos (2004), He and Krishnamurthy (2007)). However, our paper is the first to analyze the evolution of reputation concerns and their dynamic effects on asset allocation and prices.

The rest of the paper is organized as follows. Section 2 discusses some motivating facts. Section 3 presents a static model to highlight the basic intuition. Section 4 extends the model into a dynamic setup. Further extensions are discussed in Section 5, and Section 6 concludes. All proofs are provided in the Appendix.

2 A Static Model

This section presents a simple one-period model to illustrate the basic intuition from our dynamic model in the next section. Consider a one-period economy, $t = 0, 1$. There is a continuum of investors, with measure normalized to 1. At $t = 0$, each investor is endowed with one risk-neutral manager and decides whether to delegate his wealth \$W to the manager to invest. A manager may be either a "good" type g or a "bad" type b, and the type is observable only to the manager himself. A manager's *reputation* ρ_t is defined as investors' perceived likelihood at time t that the manager is type g. We assume all managers have the same initial reputation ρ_0 at $t = 0$.

Both types of managers, but not the investors, have access to two trading strategies, whose returns are realized at $t = 1$. In this baseline model, these returns are exogenously given and are assumed to have a binary distribution. We subsequently sketch a simple way to endogenize asset prices to study the price impact induced by managers' trading activities. Within each strategy, type g managers can generate higher returns than type b ones. More specifically, if a type j manager (for $j = g, b$) invests in strategy i (for $i = 1, 2$), his return at $t = 1$ is given by:

$$r_i = \begin{cases} r_i^+ & \text{with a probability } p_i^j, \\ r_i^- & \text{otherwise.} \end{cases} \tag{1}$$

Type b managers have lower probabilities for achieving the high returns r_i^+, i.e., for $i = 1, 2$,

$$p_i^b < p_i^g.$$

For simplification, we assume the investment outcomes are independent across managers.

We set $r_1^- \ll r_1^+$ and let p_1^g and p_1^b be close to 1. That is, strategy 1 is a "nickel-picking" strategy, generating frequent small gains (r_1^+) with rare large losses (r_1^-). In contrast, relative to strategy 1, strategy 2 is less likely to generate the high return r_2^+, i.e., for $j = g, b$,

$$p_2^j < p_1^j.$$

In the extreme case in which p_2^j is close to 0, strategy 2 is a bet on a small-probability event: it leads to small losses (r_2^-) most of the time but generates large profits (r_2^+) when the small-probability event occurs. For expressional convenience, we say that a manager *fails* in a strategy if he gets the low return from the strategy (r_1^- or r_2^-), and that a manager *succeeds* in a strategy if he gets the high return (r_1^+ or r_2^+). In summary, we assume that managers are very likely to succeed in strategy 1 but occasionally incur large losses. Relatively speaking, managers are less likely to succeed in strategy 2.

After getting the capital \$W from his investor at $t = 0$, the manager chooses whether to invest the capital into strategy 1 or strategy 2. That is, we assume that the manager cannot borrow or lend. In addition, he must focus on one strategy to reflect the fact that the manager may need to set up the infrastructure for trading in the strategy and can only keep personnel specialized in one strategy. We use the notation

$$\bar{r}_i^g \equiv E_0 \left[r_i | j = g \right] = p_i^g r_i^+ + (1 - p_i^g) r_i^- \tag{2}$$

to denote a type g manager's expected return from strategy i, $i \in \{1, 2\}$, and

$$\bar{r}_i^b \equiv E_0 \left[r_i | j = b \right] = p_i^b r_i^+ + (1 - p_i^b) r_i^- \tag{3}$$

to denote a type b manager's expected return.

At $t = 1$, the return r_i is realized and the investor rationally updates the manager's reputation $\rho_1 \equiv \Pr(g|r_i)$. Note that because $r_1 \neq r_2$, investors can infer the strategy chosen by their

manager from the realized return. That is, we essentially assume that the investor is sophisticated and informed enough to figure out the manager's strategy after checking the manager's book ex post. This assumption reflects the sophistication of typical big hedge fund investors—endowments, pension funds, or funds of funds. As will become clear, relaxing this assumption by introducing less sophisticated investors is likely to amplify the impacts in our model and make the nickel-picking strategy 1 even more appealing to managers.

For simplicity, we assume that all investors have the same outside option, such that investors would keep a manager whenever the manager's reputation is not lower than some constant $\underline{\rho}$, with $0 \leq \underline{\rho} < \rho_0$. This implies that investors find it optimal to delegate their capital to their managers at $t = 0$. At $t = 1$, however, an investor would keep his manager if $\rho_1 \geq \underline{\rho}$ and fire the manager otherwise. To capture the idea that being fired is costly to the manager, we model it in a reduced form: We assume that if a manager is kept at $t = 1$, he gets an extra "bonus" V beyond his base compensation. If the manager is fired at $t = 1$, however, he will not get this bonus.[4] The bonus V is meant to capture the manager's career value: the present value of the manager's loss of income over the rest of his career when he is fired. We choose this reduced-form formulation in our baseline model for clarity in our analysis and will endogenize this career value in a dynamic setup.

Beyond the bonus V, we assume that managers' compensation takes the form of a fixed share ϕ of the profit or loss he generates. This assumption perfectly aligns the interests of investors and managers, except for the reputation concern. Hence, we can isolate and focus our analysis on the impact from reputation concerns only. Moreover, this assumption can be partly justified by the common practice that managers often invest a significant amount of personal wealth in their hedge funds, and so share part of the profits and losses.[5] All managers are risk neutral and so each manager's objective is to choose a strategy $a \in \{1, 2\}$ to maximize his expected overall payoff

$$\max_{a \in \{1,2\}} E\left[\phi W r_a + \Pr(\rho_1 \geq \underline{\rho}) \times V\right], \tag{4}$$

where $\phi W r_a$ is the compensation at $t = 1$, and $\Pr(\rho_1 \geq \underline{\rho})$ is the probability for the manager to

[4] This assumption implies that once the manager loses his job, his utility is less sensitive to his reputation level. This structure is similar to the model in Zwiebel (1995), who analyzes the impact of reputation on corporate conservatism.

[5] Another popular feature in hedge fund managers' compensation is that managers share profits but not losses. This convexity in managers' payoffs clearly has a significant impact on the manager. We show in the Appendix that incorporating this option-like compensation structure does not affect our main results.

be kept, in which case the manager also gets the bonus V.[6] For notational clarity, without loss of generality, we normalize $\phi W \equiv 1$. The tendency for a risk-neutral agent to take an infinite position is curbed by our earlier assumption that the manager cannot borrow or lend and has to focus on one strategy. This modeling choice is similar to that in Abreu and Brunnermeier (2002), who point out that limits to positions can be attributed to, among other things, wealth constraints, asymmetric information, and risk aversion.

Note that in the case of $V = 0$, the manager has no career concern and simply chooses the strategy with a higher expected return. Since there is no career value, type b managers always take the strategy with a higher expected return, even if doing so reveals their type. Similarly, if the career value is very small, type b managers are also willing to reveal their type in order to take the strategy with a higher expected return. In our analysis below, we will focus on the more interesting case where managers' reputation concern is more important. Specifically, we assume

$$p_2^b V > |\bar{r}_2^b - \bar{r}_1^b|. \tag{5}$$

Intuitively, the above inequality implies that the career value is so large that a type b manager would not choose to fully reveal his type. We also make the following technical assumption: For any $x \in \{p_1^g, 0, 1\}$, $y \in \{p_2^g, 0, 1\}$,

$$\bar{r}_1^g + xV \neq \bar{r}_2^g + yV. \tag{6}$$

Intuitively, this assumption rules out the zero-measure special cases in which a type g manager finds both strategies equally attractive and so doesn't have a strict preference. Lastly, we restrict our attention in this paper to pure strategies–that is, we rule out the case where managers flip a coin to decide their strategy.

2.1 Reputation updating

As discussed previously, we are interested in the pooling equilibrium, in which type b managers choose not to fully reveal their type. Upon observing the investment outcome, r_i, investors apply

[6]The assumption that the manager chooses between these two strategies implicitly assumes that the manager's outside option is dominated by at least one of the two strategies.

Bayes' rule to update their managers' reputations:

$$\rho_1 \equiv \Pr(g|r_i) = \frac{\Pr(r_i|g) \times \rho_0}{\Pr(r_i|g) \times \rho_0 + \Pr(r_i|b) \times (1 - \rho_0)}, \tag{7}$$

where $\Pr(r_i|g)$ is investors' perceived probability for a type g manager to generate a return r_i and $\Pr(r_i|b)$ the perceived probability for a type b manager to get r_i. For example, $\Pr(r_1^+|g)$ is investors' perceived probability for a type g manager to choose strategy 1 and succeed, which is determined not only by p_1, the probability for a type g manager to succeed in strategy 1 if he chooses the strategy, but also by the perceived probability for a type g manager to choose this strategy in the first place.

We can rewrite $\Pr(r_i|g)$ as

$$\Pr(r_i|g) = \Pr(r_i|g, a = i) \times I_i^g, \tag{8}$$

where $\Pr(r_i|g, a = i)$, given by equation (1), is the probability that a type g manager earns a return r_i conditional on choosing strategy i; and I_i^g is investors' expectation of the probability for a type g manager to choose strategy i in the first place, which, under the rational expectations assumption, is also the fraction of type g managers who choose strategy i. Likewise, $\Pr(r_i|b)$ can be expanded as $\Pr(r_i|b, a = i) \times I_i^b$, where I_i^b is the fraction of type b managers who choose strategy i.

Note that (6) implies that the managers always strictly prefer one strategy over the other, and that I_i^g can only be either 0 or 1. Moreover, as we will see in equilibrium, type b managers' strong incentive to mimic type g managers ensures that $I_i^b = I_i^g$. The following lemma summarizes a manager's reputation after his return is realized in the case of $I_i^b = I_i^g = 1$.

Lemma 1 *For strategy $i \in \{1, 2\}$, define*

$$\rho_i^* \equiv \frac{\underline{\rho}(1 - p_i^b)}{1 - [(1 - \underline{\rho})p_i^g + \underline{\rho}\ p_i^b]}. \tag{9}$$

Suppose $I_i^g = I_i^b = 1$. Consider a manager in strategy i. If $\rho_0 \geq \rho_i^*$, then the manager can keep his job regardless of his return. If $\rho_0 < \rho_i^*$, however, then the manager can keep his job if he succeeds, but loses his job if he fails.

The above Lemma makes the intuition for reputation concern clear. If a manager has a very high initial reputation ($\rho_0 \geq \rho_i^*$), a failure in his investment brings down his reputation, but not enough to cost him his job. Hence, this high-reputation manager does not have a career concern in his decision making.[7] In contrast, if a manager's initial reputation is not very high ($\rho_0 < \rho_i^*$), the manager is right on the verge of being fired and an investment failure is enough to cost him his job–i.e., the manager can keep his job only if his investment succeeds, a scenario with a probability of p_i^j. As a result, this relatively low-reputation manager is very concerned about his career in his decisions and may be willing to forgo profitable investment opportunities in order to keep his job safe.

To completely describe the managers' choice, we need to specify the potential treatments they receive if they choose a strategy that investors do not expect them to take. For example, if investors expect managers to take strategy 1 (i.e., $I_1^g = I_1^b = 1$), what happens to a manager's reputation if he takes strategy 2? To describe the reputation updating in this case, we need to make an assumption on the investors' perception about the type of the managers who may take the unexpected strategy 2. The assumption we adopt here is that there is an infinitesimal fraction (zero measure) of the managers who, for reasons outside our model, have a 50% chance of choosing each strategy. To make it easy to refer to those managers in our discussions, we call them "restricted" managers and refer to those other managers who can choose freely as "unrestricted" managers. Restricted managers are otherwise indistinguishable from unrestricted managers. Among these restricted managers α, with $0 < \alpha < 1$, of them are type g and the rest are type b.

This assumption ensures that in equilibrium all strategies are chosen by some managers, so that reputation updating is always well defined. The reason we assume the mass of the restricted managers is zero is to simplify the calculations. The analysis will be similar, but more complex, if we assume the mass of restricted managers is finite.

Clearly, the value of α plays an important role in a manager's decisions. Intuitively, α determines investors' tolerance of managers who take an unexpected action. For example, suppose $I_1^g = I_1^b = 1$,

[7]The result that the high-reputation manager does not care about the impact on his reputation at all is specific to this static model. As will become clear in the dynamic model in Section 3, the high-reputation manager also cares about the impact on his reputation, but to a lesser extent relative to low-reputation managers.

that is, investors believe almost all unrestricted managers would choose strategy 1. How should investors update the reputation of a manager who chooses strategy 2? The manager might be one of those restricted managers, whose ex ante reputation is α. Hence, holding everything else constant, a high α would attract managers to unexpected strategies, and a low α would drive managers away from them. In this section, we assume

$$\alpha = \rho_0. \tag{10}$$

That is, the restricted managers are a representative subgroup of the whole population of managers. This perhaps is the most natural benchmark case. In our analysis in Section 4, we consider more general cases and discuss the ensuing additional insights.

2.2 Equilibrium with reputation concerns

Definition 1 The *equilibrium* is defined by $\{I_i^j \mid j \in \{g, b\} \text{ and } i \in \{1, 2\}\}$, such that managers' actions solve (4), given that investors update reputation according to (7) and (10).

Note that $I_1^j + I_2^j = 1$, hence we can characterize the equilibrium by I_1^j only, since it immediately pins down I_2^j. In the following proposition, we first characterize an equilibrium of interest, and postpone the discussion on the multiplicity and stability of the equilibrium to Section 2.4.

Proposition 1 *For the economy defined above, an equilibrium is given by*

$$I_1^g = I_1^b = 0, \quad \text{if} \quad \bar{r}_2^g > \bar{r}_1^g + R, \tag{11}$$

$$I_1^g = I_1^b = 1, \quad \text{if} \quad \bar{r}_2^g < \bar{r}_1^g + R, \tag{12}$$

where the value of R is characterized by the following three cases:

1. *if $\rho_0 < \min(\rho_1^*, \rho_2^*)$, then $R = (p_1^g - p_2^g)V$;*
2. *if $\rho_0 \geq \max(\rho_1^*, \rho_2^*)$, then $R = 0$;*
3. *otherwise, $R = (1 - p_2^g)V$ if $\rho_1^* \leq \rho_0 < \rho_2^*$, and $R = (p_1^g - 1)V$ if $\rho_2^* \leq \rho_0 < \rho_1^*$.*

The above proposition describes how the resulting equilibrium changes as a function of the manager's initial reputation, ρ_0, and of the attractiveness of the two strategies, $\bar{r}_1^g, \bar{r}_2^g$. As illustrated in

(11) and (12), due to reputation concerns, managers do not necessarily choose the strategy with the higher expected return. In particular, the two strategies are equally attractive to managers when the nickel-picking strategy 1's expected return is lower than strategy 2's by R. That is, reputation concern makes strategy 1 appealing, and managers are willing to forego the alternative strategy that offers an extra expected return up to R. Following Dasgupta and Prat (2006, 2008), we call R the "reputation premium."

As shown in the three cases, this reputation premium varies across the initial reputation level ρ_0. In case 1, the manager has a very low initial reputation level, and $\rho_0 < \min(\rho_1^*, \rho_2^*)$ implies that the manager will be fired if he fails regardless of his strategy choice. Sitting on the verge of being fired, the manager has a strong incentive to reduce his chance of failing a strategy. Strategy 1 has a relatively small probability for failure, making it very appealing to managers with strong reputation concerns. For the alternative strategy 2 to be equally attractive to the manager, it has to offer a high reputation premium $R = (p_1^g - p_2^g)V$.

This reputation concern is significantly weakened if the manager's initial reputation level is high. As shown in case 2, when the manager has a very high initial reputation level—that is, when $\rho_0 \geq \max(\rho_1^*, \rho_2^*)$—then he will not be fired regardless of his strategy choice and the final outcome. The manager then has no reputation concern and prefers the strategy with a higher expected return. That is, two strategies are equally attractive if they offer the same expected return, and the reputation premium is zero. Note that the implication of no-reputation concern (i.e., $R = 0$) is due to the static nature of this baseline model. As shown later in Section 3 in a dynamic model, a high-reputation manager has a smaller, rather than no, reputation concern, because a failure would reduce his reputation and make his future less secure.

The intuition is similar for case 3, in which the manager's initial reputation level is high enough for the manager to keep his job if he fails one strategy, but not high enough for the other strategy. For example, if $\rho_1^* \leq \rho_0 < \rho_2^*$, then the manager can keep his job after a failure in the nickel-picking strategy 1 but not after a failure in strategy 2. This would make strategy 1 more attractive and increase the reputation premium to $(1 - p_2^g)V$. In contrast, if $\rho_2^* \leq \rho_0 < \rho_1^*$, then the manager can keep his job after a failure in strategy 2 but not after a failure in strategy 1. This makes strategy

1 unappealing, leading to a negative reputation premium.

We visualize the results in Proposition 1 in Figure 1. To simplify the plot, we set

$$\frac{1-p_1^g}{1-p_1^b} = \frac{1-p_2^g}{1-p_2^b}. \tag{13}$$

This implies that a failure in the two strategies reduces the reputation by the same amount. Hence, this assumption implies $\rho_1^* = \rho_2^*$ and so eliminates case 3 and simplifies our discussion. We will simply use ρ^* to denote both ρ_1^* and ρ_2^*. In Figure 1, we summarize the equilibrium by holding all parameters constant, except the initial reputation level ρ_0 and r_2^+, which determines strategy 2's expected return $\bar{r}_2^g$.

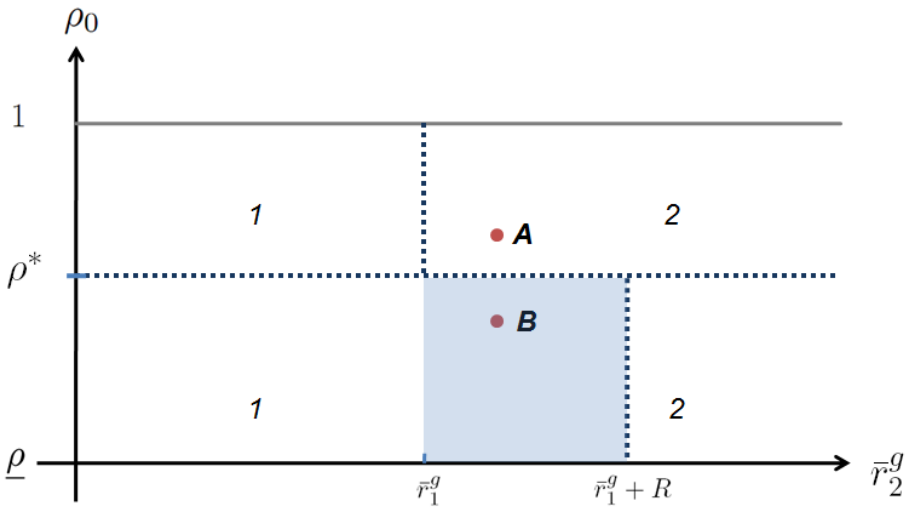


Figure 1: Equilibrium strategy choices.

This plot summarizes managers' strategy choices in equilibrium. The horizontal axis is type g managers' expected return, $\bar{r}_2^g$ and the vertical axis is the initial reputation, ρ_0. The plot summarizes the equilibrium strategy choice by varying ρ_0 and r_2^+. The region is marked as $i \in \{1, 2\}$ if $I_i^g = I_i^b = 1$ in equilibrium.

The plot clearly illustrates the distortion of reputation concern on the strategy choices. When the manager's initial reputation is low ($\rho_0 < \rho^*$), reputation concerns make the nickel-picking strategy 1 appealing to the managers. As illustrated in the figure, managers are willing to take strategy 1 as long as $\bar{r}_1^g > \bar{r}_2^g - R$. That is, in the shaded region on the plot, the low-reputation managers are willing to choose strategy 1 and forgo the more profitable strategy 2. In contrast,

if the manager's initial reputation is high ($\rho_0 > \rho^*$), this distortion in strategy choice disappears and managers simply choose the strategy with a higher expected return. These results lead to a number of implications.

2.3 Implications

2.3.1 Popularity of nickel-picking strategies

First, among managers whose careers are not safe, nickel-picking strategies are popular even when they pay a lower expected return. Intuitively, if a manager chooses alternative strategies, which offer higher expected returns but also higher likelihood for losses, then he is likely to incur some losses before reaping the expected profit. In the meantime, as his reputation suffers following each loss, the manager faces the risk of being fired before the profits arrive. To the extent that the manager is concerned about this risk, he may choose the nickel-picking strategy even if it offers a lower expected return.

Some anecdotes from the recent financial crisis illustrate the phenomenon. Despite repeated warnings of the housing bubble before 2007,[8] consistent with our model, most market participants did not find fighting the housing bubble appealing. In fact, many institutions took the other side of the trade, suffering collective losses of billions of dollars.[9] Fighting the housing bubble is the opposite of a nickel-picking strategy, and it is a daunting task in our model for managers with reputation concerns: Suppose someone was convinced that the subprime crisis was emerging in 2005. He could buy credit default swaps (CDS) on assets backed by subprime mortgages. Then he would expect to incur repeated losses (i.e., pay the premium for the CDS) for a long period of time before the housing bubble burst. This strategy is therefore more attractive to investors with less reputation concern. Indeed, a casual look at the ex post high-profile winners in this crisis suggests this might be the case: They either implemented the strategy using their personal wealth or made an extra effort to convince their investors to stay the course.[10] Similarly, Brunnermeier and Nagel

[8] See, e.g., "The Bubble's New Home," *Barron's*, June 20, 2005, "Be Warned: Mr Bubble's Worried Again," *New York Times*, August 21, 2005.

[9] "How High Will Subprime Losses Go?," *Wall Street Journal*, December 27, 2007.

[10] For examples of investing with personal wealth, see "Tiger's Julian Robertson roars again," *CNNMoney.com*, January 29, 2008; "In Beverly Hills, A Meltdown Mogul Is Living Large," *Wall Street Journal*, January 15, 2008. For the case of a hedge fund dealing with its investors' pressure while betting on the crash of the housing bubble, see

(2004) document that during the technology bubble in the late 1990s, many hedge funds did not find fighting the bubble appealing and, instead, were heavily invested in technology stocks.

While these anecdotes are eye-catching, they might reflect unusual behavior during rare bubbles. Recall that nickel-picking strategies are those which observe frequent small gains and rare large losses–i.e., negatively skewed return distributions. In order to test whether the anecdotes are consistent with the systematic behavior of fund managers over time, we collect the monthly returns (January 1994 to April 2008) of the constituent indices of the Credit Suisse/Tremont Hedge Fund index and calculate the skewness of individual index returns. There are ten style-based constituent indices, and member funds are assigned to a particular style based on self-reported information. The results are shown in Table 1.

The evidence suggests that nickel-picking strategies are indeed very popular among hedge fund managers: four out of the ten style indices, representing more than 40% of the assets of Hedge Fund Index member funds, are negatively skewed at the 5% level. It is particularly interesting to note that the "multi-strategy" index is negatively skewed, suggesting that when a fund does not restrict its strategy choice, managers tend to select nickel-picking strategies. In contrast, only one index, "Dedicated short bias," representing only 0.6% of hedge fund assets, is significantly positively skewed.[11]

Note that because these calculations are performed using indices rather than individual fund returns, there is a bias against finding significance: If strategy returns were independent across the individual component funds, then by the law of large numbers, the aggregate of these returns would display little or no skewness. This suggests that returns of hedge funds in the same strategy are highly correlated and that the skewness in individual funds' return is likely to be even larger than that presented in the table.

"Trader Made Billions on Subprime," *Wall Street Journal*, January 15, 2008.

[11]The skewness of certain trading strategies has been noticed in the literature. For example, Mitchell and Pulvino (2001) find that returns to merger arbitrage are similar to those from selling put options, and Duarte, Longstaff, and Yu (2007) show that some fixed income arbitrage strategies can produce positively skewed returns.

2.3.2 Cross-sectional implications

Reputation concerns distort managers' strategy choices and hence naturally affect managers' performance. Low-reputation managers may have to forgo profitable strategies due to reputation concerns. This impact is much weaker on high-reputation managers, suggesting that reputation concerns can also have a significant impact on managers' relative performance. When a profitable opportunity arises, the managers with more reputation concerns – lower reputation ρ_0 – are more reluctant to exploit this opportunity if it is likely to lead to temporary losses. As a result, holding managers' skill constant, the ones with fewer reputation constraints would outperform. Hence, even persistent differences in returns over time are not necessarily reliable indicators of differences in managers' ability. They may simply reflect the differences in reputation concerns. This result complements the insight in Berk and Green (2004) that performance might not be a good measure of ability because high-ability managers attract more assets and, due to decreasing returns to scale, do not necessarily deliver better performance.

Moreover, fluctuations in the size of the hedge fund industry may have implications for the industry average return. For example, Fung and Hsieh (2006) document at least a tenfold increase in assets under management and a fourfold increase in number of funds, over the decade 1994–2004. Due to this explosive growth of the hedge fund industry, it is likely that more and more managers with mediocre reputation (ρ_0 being close to $\underline{\rho}$) joined the industry. Due to their less convincing track records, these managers are more likely to forgo profitable opportunities in order to avoid risking their career. This naturally leads to less impressive performance. In contrast, the financial crisis of 2007–2009 has significantly reduced the number of funds (Brown et al., 2009). To the extent that this crisis has an impact on the managers' reputation, it would also affect the overall performance of the industry.

Finally, perhaps most importantly, the plot also reveals how the changes of reputation and profitability of the strategies affect the equilibrium. For example, suppose the equilibrium is at point A in the plot–i.e., managers' initial reputation is higher than ρ^* and strategy 2 has a higher expected return $\bar{r}_2^g > \bar{r}_1^g$. Hence, all managers choose strategy 2, and investors' perception is

$I_2^g = I_2^b = 1$. Suppose some poor performance brings the managers' reputation down to B in the plot. Although the fundamentals in the economy remain the same ($\bar{r}_1^g$ and $\bar{r}_2^g$ are unchanged), the equilibrium now shifts to the one in which all managers choose the less profitable strategy 1 and investors' perception becomes $I_1^g = I_1^b = 1$. This simple thought experiment shows that shocks to reputation can have a profound impact on capital relocation and hence equilibrium prices. To fully explore this intuition, however, it is necessary to develop a dynamic model with reputation concerns, which is the focus in Section 3. Before we move on to present the dynamic model, however, it is worth having some discussions on the multiplicity and stability of the equilibrium.

2.4 Multiplicity and Stability

The equilibrium constructed in Proposition 1 is natural, but other equilibria may also exist. For example, suppose ρ_0 is just above ρ^* and $\bar{r}_1^g > \bar{r}_2^g$. According to Proposition 1, managers are not concerned about their job, and in equilibrium, apart from the zero-measure of restricted managers, all managers choose strategy 1 because it has a higher expected return. However, one can construct an alternative peculiar equilibrium: In this equilibrium, almost all managers choose strategy 2 and a zero measure of type b managers choose strategy 1. It is easy to see that a type g manager does not want to deviate: Note that now the managers in strategy 1 are those restricted managers who have a reputation of just above ρ^*, and some type b managers. Therefore, the ex ante reputation of the managers in strategy 1 can be lower than ρ^*, in which case those managers in strategy 1 would lose their job if they fail their strategy. This makes strategy 2 more preferable if the excess expected return from strategy 1 is not too high (more specifically, $\bar{r}_1^g - \bar{r}_2^g < (1-p_1^g)V$). At the same time, under some parameter values, type b managers are indifferent between these two strategies.

Intuitively, in this equilibrium, a small fraction (zero measure) of type b managers "spoil" strategy 1, pushing other managers into the alternative strategy. Those type b managers are happy to stay in strategy 1 because the presence of restricted type g managers in strategy 1 keeps the ex ante reputation of the managers in strategy 1 high enough that they can keep their job if they succeed. While this peculiar equilibrium satisfies Definition 1, we show next that they are not stable according to the following definition.

Definition 2 Consider a shock x to an equilibrium i, wherein a representative fraction x, $0 < x < 1$, of the unrestricted managers in each strategy are moved to the opposite strategy. The equilibrium i is *stable* to the shock x if type g managers' solution a to (4) is unchanged by the shock. The equilibrium is *globally stable* if it is stable for all shocks x, $x \in (0, 1)$. The equilibrium is *globally unstable* if it is not stable for any shock x, $x \in (0, 1)$.

This stability definition is similar to that in DeMarzo, Kaniel, and Kremer (2007). One can see that the earlier peculiar equilibrium is not stable: the spoiling of strategy 1 arose from the imbalance of managers choosing it; after the shock, the imbalance is rectified. Type g managers would thus prefer to go back to the strategy 1, and type b managers would prefer to follow, leading to the equilibrium in Proposition 1. On the other hand, it is straightforward to verify that the equilibrium constructed in Proposition 1 is stable. In fact, as stated in the following proposition, it is the only stable equilibrium.

Proposition 2 *For the economy defined above, the globally stable pure strategy equilibrium is unique and given by Proposition 1.*

3 A Dynamic Model

In this section, we solve a dynamic model of reputation concerns to analyze the joint dynamics of the managers' reputations and strategies' popularity. Extending the model to a dynamic setting generates a time-varying reputation premium and allows us to capture a much richer set of behaviors. As managers' reputations fluctuate over time, the aggregate popularity of strategies themselves also fluctuates. Capital under the control of managers whose reputations are "on the verge" (where any further missteps would cost their career) flies quickly to strategies with smaller probabilities of suffering losses, while those managers whose reputations are already damaged choose to stay in safe strategies for multiple periods despite the existence of alternatives offering higher returns. Moreover, precisely because these strategies are safe, managers' successes there are not very informative about their ability and their reputations only recover slowly.

We first analyze a general T period model, and then illustrate the main intuition in a two-period

example.

3.1 Economic setup

We now consider an economy with T periods, $t = 0, ..., T$. Similar to Section 2, the managers now need to choose between a nickel-picking strategy 1 and an alternative strategy 2 at each time period. More precisely, at time $t-1$, for $t = 1, ..., T$, if strategy i is chosen by manager j, for $i \in \{1, 2\}$ and $j \in \{g, b\}$, the strategy return $r_{i,t}$ will be realized at time t and its distribution is given by

$$r_{i,t} = \begin{cases} r_{i,t}^{+} & \text{with a probability } p_i^j, \\ r_{i,t}^{-} & \text{otherwise,} \end{cases} \tag{14}$$

with $p_i^b < p_i^g$. To simplify our calculations, we keep the probability of success p_i^j constant over time. It is straightforward to generalize this assumption to allow time variation in the probability of success. We leave $r_{i,t}^{+}$ and $r_{i,t}^{-}$ unspecified and will specify them only in a later example. As in the baseline case, for simplification, we assume the investment outcomes are independent across managers and over time.

All managers have an initial reputation of ρ_0. At time t, after the manager's return $r_{i,t}$ is realized, investors update the manager's reputation according to Bayes' rule:

$$\rho_t \equiv \Pr(g|r_{i,t}, \rho_{t-1}) = \frac{\Pr(r_{i,t}|g, \rho_{t-1}) \times \rho_{t-1}}{\Pr(r_{i,t}|g, \rho_{t-1}) \times \rho_{t-1} + \Pr(r_{i,t}|b, \rho_{t-1}) \times (1 - \rho_{t-1})}, \tag{15}$$

where ρ_{t-1} is the manager's reputation at time $t-1$; parallel to (7), $\Pr(r_{i,t}|g, \rho_{t-1})$ is investors' perceived probability for a type g manager with a reputation of ρ_{t-1} to generate a return $r_{i,t}$ and $\Pr(r_{i,t}|b, \rho_{t-1})$ the perceived probability for a type b manager to get $r_{i,t}$. We can rewrite $\Pr(r_{i,t}|g, \rho_{t-1})$ as

$$\Pr(r_{i,t}|g, \rho_{t-1}) = \Pr(r_i|g, a_{t-1} = i) \times I_i^g(\rho_{t-1}),$$

where $\Pr(r_{i,t}|g, a_{t-1} = i)$, given by equation (14), is the probability that a type g manager earns a return r_i conditional on choosing strategy i, and $I_i^g(\rho_{t-1})$ is the fraction of type g managers with a reputation of ρ_{t-1} that have chosen strategy i at time $t-1$ in the first place. In contrast,

$$\Pr(r_{i,t}|b, \rho_{t-1}) = \Pr(r_i|b, a_{t-1} = i) \times I_i^b(\rho_{t-1})$$

where $\Pr(r_{i,t}|b, a = i)$ is given by equation (14), and $I_i^b(\rho_{t-1})$ is the fraction of type b managers with a reputation of ρ_{t-1} that have chosen strategy i at time $t-1$ in the first place. Managers are fired whenever their reputations fall below $\underline{\rho}$, and their outside option value is assumed to be zero.

A manager's objective function is

$$\max_{a_t \in \{1,2\}} E_0 \left[\sum_{t=0}^{T-1} \phi W_t r_{t+1} \mathbf{1}_t + V \mathbf{1}_T \right], \tag{16}$$

where W_t is the value of assets under management, which may fluctuate over time, perhaps due to capital inflows and outflows, the profits and losses from the investment during the prior period, etc.;[12] r_{t+1} is the return from the strategy chosen by the manager at time t; $\mathbf{1}_t$ is an indicator function that is 0 if the manger's reputation has fallen below $\underline{\rho}$ before time t, and is 1 otherwise. The first term in objective (16) is the sum of the manager's future management fees. The second term says that the manager gets a bonus V if he can keep his job until time T. This is to capture the notion that reputation has some value to the manager even if he leaves the industry, and to keep the structure similar to the static model. As in the static case, we normalize $W_0\phi = 1$ without loss of generality. Similar to the assumption (5), we assume the value of V is large enough so that type b managers never prefer to fully reveal their type.[13] Moreover, similar to assumption (6), we avoid the cases where type g managers find the two strategies indifferent, by assuming that type g managers always choose strategy 1 in those cases. This assumption has no material impact on our discussions since those cases have a zero measure. Therefore, at each point in time t, $I_{i,t}^g = I_{i,t}^b$ and can only take the value of 0 or 1. Finally, it is useful to adopt the the notation $\bar{r}_{i,t}^j \equiv p_i^j r_{i,t+1}^+ + (1 - p_i^j) r_{i,t+1}^-$, for $i \in \{1, 2\}$ and $j \in \{g, b\}$, to refer to a type j manager's time-t expected return from strategy i over the next period.

Similar to assumption (10) in the static model, we assume that for $t = 1, ..., T$,

$$\alpha_t = \rho_{t-1}. \tag{17}$$

That is, for the group of managers with a reputation level ρ_{t-1}, as in the static model, there is

[12] For now, we leave the dynamic of W_t unspecified, except that we assume that the expectations in all the equations here are well defined. We will specify the dynamic of W_t in our later example in Section 3.2 to obtain a more explicit solution to this optimization problem.

[13] One can set $V = 0$ to remove the second term. The analysis for this case remains very similar. Not surprisingly, when t is close to T, a type b manager has little incentive to pretend to be of type g in this case.

an infinitesimal fraction of restricted managers who have a 50% chance of choosing each strategy. Out of these restricted managers, α_t of them are type g and the rest of them are type b. That is, assumption (17) implies that the restricted managers are a representative subsample of this group of managers with a reputation level ρ_{t-1}. Whether a manager is restricted is independent across managers and over time. We leave the discussion of more general assumptions on α_t to Section 4.

We denote the type g manager's value function as V_t. If the manager has not been fired at time t, V_t is given by

$$V_t = \max_{a_\tau \in \{1,2\}} E_t \left[\sum_{\tau=t}^{T-1} \phi W_\tau r_{\tau+1} \mathbf{1}_\tau + V \mathbf{1}_T \right], \tag{18}$$

for $t = 0, 1, ..., T-1$, and

$$V_T = V \mathbf{1}_T. \tag{19}$$

Otherwise, if the manager has been fired before time t, we have

$$V_t = 0, \tag{20}$$

since, by assumption, the manager's outside option has zero value. Naturally, one can interpret V_t as the reputation value. Note that this dynamic problem can potentially have a large number of state variables, including the manager's reputation level, assets under management, and all his future potential investment opportunities.

If a type g manager has not been fired by time t, his Bellman equation is given by

$$V_t(\rho_t, W_t, A_t) = \max_{a_t \in \{1,2\}} E_t \left[\phi W_t r_{a,t+1} + V_{t+1} \right], \tag{21}$$

where $A_t = \{\bar{r}^g_{i,\tau},$ for $i \in \{1,2\}$ and $\tau = t, ..., T\}$ summarizes all the future investment opportunities for the manager.

Definition 3 The *equilibrium* is defined by $\{I^j_{i,t}(\rho_{t-1}) \mid j \in \{g,b\}$ and $i \in \{1,2\}$ and $0 \leq t < T\}$, such that managers' actions solve (16), given that investors update reputation according to (15) and (17).

Proposition 3 *For the economy defined in this section, the stable equilibrium is such that for the*

managers with a reputation of ρ_t, their choice is given by

$$I_1^g(\rho_t) = I_1^b(\rho_t) = 0, \quad \textit{if} \quad \bar{r}_{2,t}^g > \bar{r}_{1,t}^g + R_t, \tag{22}$$

$$I_1^g(\rho_t) = I_1^b(\rho_t) = 1, \quad \textit{if} \quad \bar{r}_{2,t}^g < \bar{r}_{1,t}^g + R_t, \tag{23}$$

for $t = 0, ..., T-1$, where the value of R_t is given by:

$$R_t = \frac{E_t[V_{t+1}|a_t = 1] - E_t[V_{t+1}|a_t = 2]}{\phi W_t}, \tag{24}$$

where V_t can be obtained by backward induction from equations (18)–(21).

This proposition illustrates that reputation concerns play an important role in determining managers' choices, leading to a time-varying reputation premium in this dynamic setup. Reputation concerns make the nickel-picking strategy 1 appealing to managers. At time t, the reputation premium R_t is the excess expected return that is needed to induce the manager to choose strategy 2. This reputation premium changes over time when the manager's reputation, assets under management, and investment opportunities change. As shown in equation (24), reputation premium is determined by the difference of the expected next period reputation value from the two strategies. In particular, $E_t[V_{t+1}|a_t = 1]$ and $E_t[V_{t+1}|a_t = 2]$ are the manager's expected reputation values if he chooses, respectively, strategies 1 and 2. Hence, the numerator is the expected excess reputation value of strategy 1. Scaling it by the effective size of the manager's investment gives the reputation premium R_t—the expected excess return required to make strategy 2 equivalent to strategy 1.

It is easy to see some properties of R_t. For example, $R_t = 0$ if the manager's initial reputation is extremely high. Intuitively, if a manager's reputation is so high that he will not be fired even if he repeatedly fails his strategy T times, then this manager always ignores the impact on his reputation and chooses the more profitable strategies. In contrast, a manager with a lower reputation will adjust his strategy choices to accommodate his reputation concerns. To see the profound impacts of reputation concerns, we explicitly work out the following two-period example.

3.2 A two-period example

We now consider a two-period example–i.e., $T = 2$. To simplify our calculations, we make three assumptions. The first one is to simplify the fluctuation of assets under management. We assume

that at the end of each period, if investors decide not to fire the manager, they adjust the assets under management back to the initial level. That is, if the fund made a profit during the period, the manager takes a fraction ϕ of it and distributes the rest of the profit back to investors; if the fund incurs a loss and investors decide not to fire the manager, they will further invest in the fund and bring the assets under management back to the initial level. The second simplification is that $r_{i,t}^{+}$ and $r_{i,t}^{-}$, for $t = 1, 2$, are known at period 0. That is, the return distributions of the manager's strategies are not state contingent. The final simplification is to maintain (13), which implies ρ_1^* and ρ_2^*, given by (9), have the same value. Hence, we will simply use ρ^* to denote them. Relaxing these three assumptions is straightforward but adds little insight to our later analysis. The equilibrium in this example is given by the following proposition.

Proposition 4 *The equilibrium in this two-period example is summarized in (11) and (12) for* $t = 0, 1$, *and* $R_1 = (p_1^g - p_2^g)V$ *if* $\rho_1 < \rho^*$ *and* $R_1 = 0$ *if* $\rho_1 \geq \rho^*$; *and* R_0 *is given by*

$$\begin{aligned}
&\textit{case 1:} \quad R_0 = 0 && \textit{if } \rho_0 \geq \rho^h && (25)\\
&\textit{case 2:} \quad R_0 = (p_1^g - p_2^g)(V^h - V^l) && \textit{if } \rho^h > \rho_0 \geq \rho^* && (26)\\
&\textit{case 3:} \quad R_0 = (p_1^g - p_2^g)V^h && \textit{if } \rho^* > \rho_0 \geq \rho^l && (27)\\
&\textit{case 4:} \quad R_0 = p_1^g V^l - p_2^g V^h && \textit{if } \rho^l > \rho_0 \geq \underline{\rho} && (28)
\end{aligned}$$

for the constants V^h, V^l, ρ^h, *and* ρ^l *given in the Appendix.*

The analysis in the last period is the same as in Proposition 1 in Section 2. If the manager's reputation at $t = 1$, ρ_1, is higher than ρ^*, then the manager has no reputation concern and chooses the more profitable strategy. Hence, the reputation premium $R_1 = 0$. However, if $\rho_1 < \rho^*$, the reputation concern makes the nickel-picking strategy 1 more appealing, leading to a reputation premium $R_1 = (p_1^g - p_2^g)V$.

The impacts of reputation concerns on the manager's choices at $t = 0$ can be summarized in four cases. As shown in case 1, if the manager's reputation is extremely high, $\rho_0 \geq \rho^h$, he is not concerned about his reputation since he will not lose his job even if his strategy fails in both periods. Hence, the manager will simply choose the more profitable strategy and the reputation premium

is zero. In case 2, the manager's reputation is reasonably high, $\rho^h > \rho_0 \geq \rho^*$. He can keep his job if his strategy fails once, but loses his job if his strategy fails in both periods. This reputation concern makes strategy 1 appealing, leading to a reputation premium, given by equation (26), the amount of the expected return that the manager is willing to give up in order to choose strategy 1. If the manager's reputation is still lower, $\rho_0 < \rho^*$, he has a even stronger reputation concern since he will lose his job right away if he fails once. There are two subcases here, as summarized in cases 3 and 4. In case 3, the manager's reputation is not too low and a success this period in either strategy is enough to boost his reputation to the level at which he does not have to worry about his reputation in the next period–i.e., $\rho_1 \geq \rho^*$. Relative to case 2, the reputation concern here is stronger, making strategy 1 even more appealing and leading to a even higher reputation premium in equation (27). The manager's reputation level is even lower in case 4, and a success in strategy 1 is not enough to increase his reputation above ρ^*, and hence the manager still has reputation concern in the second period. Note that a success in strategy 2 increases a manager's reputation more than a success in the nickel-picking strategy 1.[14] In fact, a success in this strategy increases a manager's reputation above ρ^* so that the manager has no reputation concern in the next period. This makes strategy 2 appealing to managers and so makes the reputation premium in case 4 lower than that in case 3. The fluctuations of reputation in equilibrium lead to a number of implications.

3.3 Implications

Due to reputation concerns, capital can sometimes appear to be slow moving, leaving attractive opportunities unexploited, while other times it appears capricious, leading to large capital relocation while there is little or no information about the fundamentals. Several vivid cases are documented in Mitchell, Pedersen, and Pulvino (2007), which fit with our model implications nicely. For example, Mitchell, Pedersen, and Pulvino (2007) show that before the end of 2004, convertible

[14]It is easy to see from equation (7) that a success in strategy 2 leads to a bigger increase in reputation than a success in strategy 1 under the condition $p_1^g/p_1^b < p_2^g/p_2^b$, which is guaranteed by assumption (13). Intuitively, for the nickel-picking strategy 1, a type b manager's success probability p_1^b is already large, and so p_1^g/p_1^b tends to be small. Hence, the condition $p_1^g/p_1^b < p_2^g/p_2^b$ is likely to hold. Of course, more generally, this condition can be violated. In that scenario, case 4 would disappear.

bond arbitrage funds were very popular and collectively managed around $40 billion of assets. After some disappointing returns, however, this strategy quickly went out of fashion in 2005, and the total assets under management fell by half within a span of three months. Interestingly, the authors also note that the typical convertible bond arbitrage strategy appeared to be more profitable in 2005 and this seemingly profitable opportunity appeared to last well into 2006 (the end of their sample). This extensive delay for capital to move back is puzzling, and the authors dub it "slow-moving capital." In light of our model, however, the whole episode is a natural phenomenon: Suppose the managers have a fairly good reputation at $t = 0$. Given the limited reputation concerns, managers find the convertible bond arbitrage strategy appealing. After some losses, however, those managers' reputation level drops, leading to stronger reputation concerns and making the convertible bond arbitrage strategy unappealing. This leads to drastic capital relocation, similar to the phenomenon observed in late 2004 and early 2005.

More interestingly, the model also explains the ensuing phenomenon of slow-moving capital. Now that the managers have a relatively low reputation, they are so concerned about their career that before they finally get back to a high reputation level, they prefer to manage their capital using a safer strategy rather than the convertible bond strategy, even if the latter offers a higher expected return. This leads to slow-moving capital if rebuilding reputation is a very slow process.

More subtle is the reason why it is slow to rebuild reputation. As explained earlier, due to reputation concerns, fund managers are attracted to nickel-picking strategies, which earn small positive returns most of the time but occasionally lead to dramatic losses. A natural consequence of this tendency is that the managers' reputation tends to go up gradually in small steps, but occasionally drops sharply in a big step. Put differently, by the law of iterated expectations, a manager's reputation follows a martingale. Obviously, if a martingale process goes up more often than down, the size of up-move has to be smaller than the size of down-move. This point becomes clear in the following thought experiment: Following a failure in strategy 1, how many successes in strategy 1 does it take for the manager's reputation to recover back to its original level? Following

Bayes' rule, it is easy to verify that the answer is the smallest integer n such that

$$\frac{1-p_1^g}{1-p_1^b}\left(\frac{p_1^g}{p_1^b}\right)^n \geq 1.$$

Suppose $p_1^g = 0.8$ and $p_1^b = 0.6$, i.e., a type g manager's success probability is 80% and a type b manager's is 60%. We then have $n = 4$, that is, after a failure, it takes four consecutive successes for a manager to rebuild his reputation back to its original level.

Therefore, our model offers an explanation for the phenomenon in Mitchell, Pedersen, and Pulvino (2007) that after drastic outflow induced by poor performances in a trading strategy, capital becomes slow moving–i.e., reluctant to come back. Moreover, as shown in Section 4, a simple extension of our model can also explain the increase in the expected return in that trading strategy: The increase in the expected return is perhaps due to the price impact when a large amount of capital flees from the strategy. The slow recovery of reputation and the ensuing reluctance for capital to return sustains a higher expected return for a long period of time.

Some recent studies have attempted to offer explanations for slow-moving capital. For example, He and Xiong (2009) argue that the optimal contract choice can restrict the movement of capital. Acharya, Shin, and Yorulmazer (2009) show that the tradeoff between making investments today and waiting for arbitrage opportunities in the future can lead to a shortage of capital when occasional fire sales occur. Oehmke (2009) argues that one cannot raise capital quickly if he has to sell assets in another illiquid market. Our paper complements these studies by providing an alternative, intuitive mechanism. In addition, our paper is the only one that also attempts to simultaneously explain the fact that before the slow-moving capital phenomenon, we often observe poor-performance-induced drastic capital withdrawal.

Finally, our model also provides an empirically testable implication: All else being equal, poor performance from convertible bond arbitrage funds during intolerant times (2005 and 2006) should lead to larger outflows than comparably poor performance in the more tolerant times before 2004. Another example is the convergence trading strategy. When Long-Term Capital Management (LTCM) was enjoying its early success, convergence trading became very popular. This strategy, however, quickly lost its appeal after the LTCM crisis, and the capital devoted to this strategy

is estimated to have fallen by 90% (see, e.g., MacKenzie (2005)). As in the case of convertible bond arbitrage, we again expect that, all else being equal, poor performance from convergence trading strategies should lead to larger capital outflows after the LTCM crisis than comparably poor performance before the crisis. That is, generally, our model implies that after a large amount of capital fleeing from a strategy, the expected return of this strategy tends to become higher for an extended period of time. Meanwhile, poor performance in this strategy tends to generate larger-than-usual capital outflows.

4 Discussions

4.1 Lockup

The previous analysis takes the compensation contract as given. However, one might imagine that a properly designed contract might be able to mitigate the impact of managers' reputation concerns. For example, a longer lockup period would allow the manager to have several chances to try the strategy with a low probability of success (i.e., strategy 2 in the model) before investors could withdraw capital. This is essentially equivalent to making the strategy less like a bet on a small probability event. As a result, lockup can mitigate the distortion caused by reputation concerns and the manager would be more willing to take strategy 2 as long as it offers a higher expected return.[15] However, lockups may not be completely effective in solving the problems induced by reputation concerns. First of all, the lockup period in practice is usually around one year; its impact is hence limited.[16] Second, when the expiry date of lockup restrictions approaches, the reputation concerns discussed above would rise again.

4.2 Tolerance of unpopular actions

The assumption in (10) implies that managers who choose their strategies randomly have the same reputation as the overall population. That is, this assumption by itself does not make investors

[15] A parallel argument concerns the "tenure clock" in academia. It is often argued that a longer "tenure clock" would encourage junior faculty to take on more ambitious, but risky, research projects.

[16] One of the reasons for short lockups is offered by Stein (2005): managers may have the incentive to signal their ability by voluntarily choosing a contract with a short or no lockup.

prefer or dislike managers in the unpopular strategies. Although this assumption is a natural baseline case, it is worth analyzing cases with alternative values for α.

Intuitively, α determines investors' tolerance to managers in unpopular strategies. For example, suppose $I_1^g = I_1^b = 1$, i.e., investors expect that all unrestricted managers will choose strategy 1. If a manager chooses strategy 2, then α would determine investors' perception about the manager's ability. A higher α implies that investors have a better perception of the manager's ability–i.e., investors are more tolerant of managers who use "unexpected" strategies.

We first examine the case of $\alpha < \rho_0$, that is, investors are intolerant of unexpected strategies. Intuitively, this intolerance might lead to multiple equilibria: If $I_1^g = I_1^b = 1$, then strategy 2 is unexpected and investors are intolerant of the managers who choose it. This prevents managers from choosing it and so sustains the perception $I_1^g = I_1^b = 1$. Similarly, $I_2^g = I_2^b = 1$ can also be sustained in equilibrium. Note, however, that one equilibrium is unstable to the same sort of perturbation discussed in Section 2.4. In fact, the stable equilibrium in this case remains identical to that in Section 2.

The case of $\alpha > \rho_0$ sometimes leads to nonexistence of equilibrium. Its intuition is the mirror image of the intuition for the case of $\alpha < \rho_0$: for some parameters, investors' tolerance of managers who choose the unexpected strategy makes it appealing for managers to defect from any equilibrium, ruling out the possibility of equilibrium.

4.3 Asset pricing

The baseline model abstracts away from fund managers' impact on market prices since the strategy returns are exogenously given. In practice, however, it appears that when a large volume of hedge fund capital flows into or out of a given strategy, it would put pressure on the underlying asset prices. For example, Mitchell, Pedersen, and Pulvino (2007) show that the expected return from a typical convertible bond arbitrage strategy appears to have increased when many convertible bond arbitrage funds withdrew their capital in 2005. This section briefly sketches a way to incorporate these price impacts.

Motivated by the evidence in Mitchell, Pedersen, and Pulvino (2007), we assume that the

expected return of a strategy decreases when more managers implement the strategy. In particular, to simplify the analysis, we assume that the gross return of strategy i, $\tilde{R}_i$ for $i = 1, 2$, is given by

$$\tilde{R}_i = R_i(1 - c_i X_i), \quad \text{with } 0 \leq c_i \leq 1, \tag{29}$$

where $R_i = r_i + 1$ for r_i given by (1), c_i is a constant, and X_i is the number of managers implementing strategy i. That is, R_i is the gross return of strategy i without the impact of the managers, and specification (29) implies that the "post-impact" return of the strategy decreases when it is chosen by more managers. This captures the notion that when managers implement their strategies, prices move against them (i.e., prices increase when managers need to buy but decrease when they need to sell), and this lowers the strategy's profitability. The parameter c_i measures the strength of this impact; $c_i = 0$ implies that managers have no price impact and so includes the baseline model as a special case. We can interpret c_i as a measure of the liquidity of the markets on which strategy i is implemented. The higher the c_i, the more illiquid the underlying markets are.

Combining assumption (29) with the model in Section 2, one can easily analyze the price impact caused by reputation concerns. We omit the analysis here for brevity. Nevertheless, this simple setup makes it clear that reputation concerns affect asset prices through two channels: The first one is that reputation concerns can induce managers to hold (avoid) certain assets and push up (drag down) their prices. The second and related channel is that as illustrated in Sections 2 and 3, the change in reputation may induce drastic shift in managers' strategy choices, leading to large price movements.

5 Conclusions

We have analyzed a dynamic equilibrium model of reputation concerns. Despite the simple structure, it leads to a rich set of implications, unifying a number of seemingly unrelated phenomena: It not only offers a simple explanation for why many popular hedge fund strategies are like picking up nickels in front of a steamroller (i.e., have negatively skewed return distributions) but also sheds light on the phenomenon that capital sometimes appears to be slow moving, leaving attractive opportunities unexploited, yet other times appears to be capricious, leading to large capital relocation

and price fluctuations while there appears to be no information about the fundamentals.

Our analysis focused on the case in which fund investors are fully sophisticated. One might suspect that this is too generous a characterization. We believe extending our model to capture the impact of naïve investors will be fruitful, since such investors' impact is likely to be amplified by their externalities on other investors. Moreover, in this paper, we focus on stable equilibria. It might also be fruitful to take seriously the existence of unstable equilibria, and to explore their implications for financial markets. We leave these questions to future research.

Appendix

Proof of Lemma 1

Starting from Bayes' rule (7), substitute $\underline{\rho}$ for ρ_1 and $(1-p_i^g)$ and $(1-p_i^b)$ for, respectively, type g and type b managers' probabilities to generate return r_i. Rearranging to solve for ρ_0 gives (9), the initial reputation such that the posterior reputation after a return r_i^- is $\underline{\rho}$. This naturally leads to the conclusion in Lemma 1.

Proof of Proposition 1

We need to show two things. First, we confirm that type b managers always mimic type g managers with probability one. Second, we show that under the proposed equilibrium, type g managers prefer the equilibrium strategy over any other strategy.

(i) Recall that (6) guarantees that good managers' preference is strict, so $I_i^g \in \{0,1\}$. Now suppose a positive measure δ of type b managers fails to mimic. Let ϵ be the measure of "restricted" managers in each strategy, such that a manager in the alternative strategy will have initial reputation $\rho_0' = \frac{\rho_0 \epsilon}{\epsilon+\delta}$. For any positive δ, we have $\lim_{\epsilon \to 0} \rho_0' = 0$. That means those type b managers who fail to mimic will be fired for sure, which can't be optimal for those type b managers under condition (5). Thus, type b managers mimic type g managers with probability one.

(ii) Because type b managers mimic type g managers, $I_i^g = I_i^b$. Choose i such that $I_i^g = 1$ and let $a = i$. To confirm that (11) and (12) describe an equilibrium, we need only to ascertain that type g managers strictly prefer not to deviate from the action a. Because $R = \big[\Pr(\rho_1 \geq \underline{\rho} | a=1) - \Pr(\rho_1 \geq \underline{\rho} | a=2)\big] \times V$ when $I_i^g = I_i^b$ and $\alpha = \rho_0$, the optimality of action a given (11) and (12) for type g managers, and hence (11) and (12) themselves, follows immediately from managers' objective (4).

Proof of Proposition 2

From the proof of Proposition 1, we know that in any equilibrium $I_i^g \in \{0,1\}$ and $I_i^g = I_i^b$ have to hold. There are two types of equilibria. In the first type, if $I_i^g = 1$ in equilibrium, then

type g managers prefer strategy i even if investors update reputation based on the assumption that a representative subgroup of managers are in each strategy. In the second type, however, if $I_i^g = 1$ in equilibrium, then type g managers would prefer to defect from strategy i if investors update reputation based on the assumption that a representative subgroup of managers are in each strategy. Of course, the second type of equilibrium exists because investors, correctly, expect that the managers in each strategy are not representative of the whole population of managers.

Clearly, the first type of equilibrium is globally stable: After a shock of size x ($0 < x < 1$), managers in each strategy are a representative subgroup of the whole population of managers. In the equilibrium of the first type, type g managers prefer the strategy before the shock and so the equilibrium is stable. Similarly, the second type of equilibrium is not stable. One can easily verify that any equilibrium of first type is characterized in Proposition 1 and that the equilibrium in Proposition 1 is the first type of equilibrium. This concludes the proof. The following provides a concrete example of an unstable equilibrium.

An example of an unstable equilibrium. Under the following parameter values

$$\rho_0 \geq \rho^*, \tag{30}$$

$$\bar{r}_1^g - \bar{r}_2^g < (1 - p_1^g)V, \tag{31}$$

$$\bar{r}_1^g - \bar{r}_2^g < 0, \tag{32}$$

$$\bar{r}_1^b - \bar{r}_2^b = (1 - p_1^b)V, \tag{33}$$

There exists an equilibrium, in which δ (zero measure) type b managers choose strategy 1; the rest of type b managers and all type g managers choose strategy 2, where

$$\delta = \epsilon \left(\rho_0 + \rho_0 \frac{p_1^g}{p_1^b} \frac{1 - \underline{\rho}}{\underline{\rho}} - 1 \right), \tag{34}$$

and ϵ is the size of restricted managers (which also has a zero measure). One can verify that type g managers don't want to defect to strategy 1, given conditions (30), (31), (34). Under condition (33), type b managers are indifferent between these two strategies. Finally, it is also straightforward to verify that this equilibrium is globally unstable: for a shock of any size x ($0 < x < 1$), conditions (30) and (32) imply that type g managers now prefer strategy 2.

Proof of Proposition 3

Because type b managers mimic type g managers with probability one (as in Proposition 1), it suffices to confirm that type g managers do not want to deviate. Simply note that $\phi W_t \times R_t$ is the difference in type g managers' expected value functions at $t+1$ in the case of $a_t = 1$ and in the case of $a_t = 2$. This leads to equation (24). Equations (22) – (23) follows immediately from the maximization of (16).

To see why the equilibrium is stable, consider a shock wherein a fraction x of representative, unrestricted managers is shocked into the other strategy. The proximate effect of the shock is to ensure that managers, were they to defect at time t, would be treated as having reputation ρ_0. However, note that given (17), in the constructed equilibrium, managers choose not to defect even when they would have already been treated as having reputation ρ_0m, confirming the stability of this equilibrium.

Proof of Proposition 4

Define the constants V^h, V^l, ρ^h, and ρ^l by

$$V^h \equiv \max\{\bar{r}^g_{1,1}, \bar{r}^g_{2,1}\} + V, \tag{35}$$

$$V^l \equiv \max\{\bar{r}^g_{1,1} + p^g_1 V, \bar{r}^g_{2,1} + p^g_2 V\}, \tag{36}$$

$$\rho^h \equiv \frac{(1-p^b_2)\rho^*}{(1-p^b_2)\rho^* + (1-p^g_2)(1-\rho^*)}, \tag{37}$$

$$\rho^l \equiv \frac{p^b_1 \rho^*}{p^b_1 \rho^* + p^g_1 \times (1-\rho^*).} \tag{38}$$

From Bayes' rule, ρ^h and ρ^l are such that $\rho_0 \geq \rho^h$ implies that $\rho_1 \geq \rho^*$ regardless of the outcome of the strategy; $\rho_0 < \rho^l$ implies that $\rho_1 < \rho^*$ regardless of the outcome of the strategy. Collectively, along with ρ^*, four regions are formed: $\rho_0 \geq \rho^h$; $\rho^h > \rho_0 \geq \rho^*$; $\rho^* > \rho_0 \geq \rho^l$; $\rho^l > \rho_0 \geq \underline{\rho}$.

From Proposition 1, $V_1 = V^h$ when $\rho_1 \geq \rho^*$ and $V_1 = V^l$ when $\rho^* > \rho_1 \geq \underline{\rho}$. (25) – (28) follow from the definition (24) of reputation premium R_t.

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Table 1: The Skewness of Hedge Fund Indices

Credit Suisse/Tremont Hedge Fund Index	Sector Weight	Skewness
Convertible Arbitrage	1.90%	−1.59
		(0.33)
Fixed Income Arb.	4.70%	−3.35
		(0.75)
Multi-Strategy	10.40%	−1.06
		(0.30)
Event Driven	24.40%	−3.27
		(1.42)
Emerging Markets	8.50%	−0.79
		(0.72)
Global Macro	13.80%	0.05
		(0.51)
Managed Futures	4.00%	0.02
		(0.18)
Long/Short Equity	26.40%	0.19
		(0.62)
Equity Market Neutral	5.30%	0.34
		(0.20)
Dedicated Short Bias	0.60%	0.83
		(0.38)

Table I: Data consist of the monthly returns of the constituent indices of the Credit Suisse/Tremont Hedge Fund index, beginning with the inception of the index in January 1994 until April 2008. The index consists of approximately nine hundred member funds, each with a minimum of $50 million in assets under management and at least a one-year track record, who voluntarily report monthly return information. There are ten style-based constituent indices; member funds are assigned to a particular style based on self-reported information. Style index returns are an asset-weighted combination of individual fund returns. Because some constituent indices did not report returns until April of the first year, we drop the first three months of data for our calculations. This leaves 169 monthly return observations. The construction methodology for the index rules out the backfill bias and minimizes survivorship bias (see *Credit Suisse/Tremont Hedge Fund Index Rules*, available at `http://www.hedgeindex.com`). Numbers in parentheses are bootstrap standard errors, calculated with 10,000 draws.