Reputation Concerns and Slow-Moving Capital*

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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 shows why many popular hedge fund trading strategies have negatively skewed return 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 analysis demonstrates the limitation of the role of market discipline. Fund managers may distort their investment strategies precisely *because of* certain market discipline.

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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 devoted his American Finance Association 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) in which investors' absence is taken as exogenous, is the focus of our paper.

Foreshadowing our main idea, it is interesting to note a 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 in the context of slow-moving capital, 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 for asset prices?

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 have a hard time raising more capital to invest in this strategy. The delay for capital to reenter can be substantial if rebuilding reputation is a slow process.

There can be various reasons why it takes a long time for a manager to rebuild his reputation. In this paper, we explicitly model only one. Intuitively, if a manager's job is insecure (i.e., any further missteps will cost his job), he would be attracted to strategies with small probabilities to incur losses and would 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 every now and then 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 iterated expectations, a manager's reputation (i.e., investors' expectation of their manager's ability) is a martingale. Obviously, if a martingale process goes up more often than down, the size of the up-moves has to be smaller than the size of the down-moves. As a result, after a shock in reputation, it is a slow process to rebuild his reputation back to the original level.

We formalize these ideas 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. The key ingredient of our model is that investors will

[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.

withdraw their capital once the manager's reputation falls below a certain threshold.[2] Despite its simple structure, the model delivers a rich set of implications.

First, the model shows that reputation concerns make nickel-picking strategies popular among fund managers. Indeed, 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 find nickel-picking strategies appealing. Consistent with this view, we find that the returns of hedge fund indices of many popular strategies are strongly negatively skewed (i.e., they have frequent small positive returns and rare but large losses).

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' assets under management fluctuate when their reputation levels change over time, affecting the aggregate demand for different strategies and so moving asset prices even when there is no news on fundamentals. For example, upon a big shock to a certain trading strategy, managers' performance and reputation both suffer, leading to sudden and drastic capital withdrawal, which may make the strategy 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.

[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.

These results fit nicely with the empirical evidence documented in Mitchell, Pedersen, and 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. In light of the above insights from our model, the profitability of the opportunity combined with the extensive delay for capital to move back is quite natural after managers' reputations took a big hit following their poor performance in 2004.

More broadly, the analysis demonstrates the limitation of the role of market discipline. As pointed out by Fama (1980), competition and market forces can mitigate the agency problem. Our analysis, however, shows that market discipline can exacerbate the agency problem. In our model, fund managers may distort their investment strategies precisely *because of* certain market discipline.

Our analysis is carried out in a stylized economy with a simple compensation contract for the managers in order to isolate the impact of reputation concerns. It is conceivable that a properly designed compensation contract can help to mitigate the inefficiencies (i.e., managers choose the strategy with a lower expected return). For example, one can include a lockup provision to mitigate reputation concerns; design a high-powered incentive contract to separate talented managers; or commit to penalize the managers who choose the low return strategies. While these features can certainly help to mitigate the impact of reputation concerns, the complexity in reality often makes them less effective, or even suboptimal.

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), 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), Kaniel and Kondor (2011)).

The rest of the paper is organized as follows. Section 2 presents a simple example to highlight the basic intuition. Section 3 extends the model into a dynamic setup, and its implications are summarized in Section 4. Contracting issues are discussed in Section 5, and Section 6 concludes. All proofs are provided in the Appendix.

2 An Example

This section presents a simple example to illustrate the basic intuition. Consider a one-period economy, $t = 0, 1$. There is one investor, with wealth W, and one fund manager. Both are risk neutral. The investor chooses to either delegate his wealth to the fund manager or invest in his outside option. The manager has no capital himself and invests the delegated wealth into one of the trading strategies, described below.

The manager may be either a "good" type g or a "bad" type b, and the type is observable only to the manager himself. The manager's *reputation* is defined as the investor's perceived likelihood that the manager is type g. Let the manager's initial reputation at $t = 0$ be ρ_0. After observing his manager's performance at $t = 1$, the investor follows Bayes' rule to update the manager's reputation into ρ_1.

The manager has access to two trading strategies, whose returns are realized at $t = 1$. In this example, these returns are exogenously given and are assumed to have a binary distribution.[3] For each strategy, a type g manager is more likely to generate high returns than a type b one. 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:

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

A type b manager has lower probabilities for achieving the high returns r_i^+, i.e., for $i = 1, 2$,

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

Relative to strategy 2, strategy 1 is more likely to generate the high return; i.e., for $j = g, b$,

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

That means strategy 1 is more like a "nickel-picking" strategy, generating more frequent (but smaller) gains (r_1^+) and rarer losses (r_1^-). Conversely, strategy 2 is more like a bet on a small-probability event: it leads to small losses (r_2^-) more often but generates large profits (r_2^+) when the small-probability event occurs. We use the notation

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

to denote a type j manager's expected return from strategy i, $i \in \{1, 2\}$. 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^+).

[3]Section 4.4 offers discussions on endogenizing those returns to study the price impact induced by managers' trading activities.

2.1 Objectives

We assume the investor has a simple delegation rule: he delegates his capital to the manager as long as the manager's reputation is greater than or equal to $\underline{\rho}$. At $t = 1$, the investor fires his manager (i.e., withdraws his capital) if the manager's reputation falls below $\underline{\rho}$. This is essentially to assume that the investor's outside option is that he can access a pool of managers with reputation of $\underline{\rho}$.

The manager's compensation has two parts. First, the manager earns a performance-based compensation. Second, the manager has a continuation value $V(\rho_1)$, which represents his future career value given his current reputation. We consider the simplest form of both components. Specifically, we assume that the manager's compensation takes the form of a fixed share ϕ of the profit or loss he generates. This assumption perfectly aligns the interests of investor and manager, except for the reputation concern. Hence, we can focus our analysis on the impact from reputation concerns only.[4] Second, in this illustrative example, we specify the continuation value $V(\rho_1)$ as follows:

$$V(\rho_1) = \begin{cases} V & \text{if } \rho_1 \geq \underline{\rho}, \\ 0 & \text{if } \rho_1 < \underline{\rho}. \end{cases} \tag{3}$$

That is, V represents the manager's future career value if he keeps his job, and his future career value is normalized to 0 if the manager is fired. This is meant to capture the idea that being fired is costly to the manager. It also implies that the manager's utility is more sensitive to his reputation level when his job is more insecure– i.e., his reputation is close to $\underline{\rho}$.[5] We will endogenize the continuation value V in our later dynamic model.

The manager is risk neutral, and so his objective is to choose a strategy $a \in \{1, 2\}$ to maximize his expected overall payoff

$$\max_{i \in \{1,2\}} E\left[\phi W r_i + V(\rho_1)\right]. \tag{4}$$

[4]This assumption that the manager also shares losses 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. A popular feature in hedge fund managers' compensation is that managers share profits but not losses. Incorporating this option-like structure is straightforward and does not affect our main results.

[5]This structure is similar to the model in Zwiebel (1995), who analyzes the impact of reputation on corporate conservatism.

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 in which the manager's reputation concern is more important and a type b manager prefers to mimic a type g one. Specifically, we assume

$$\bar{r}_2^b = \bar{r}_1^b. \tag{5}$$

That is, a type b manger finds the two strategies equally profitable and hence his decision is solely determined by the motivation to mimic a type g manager. Hence, our analysis below stays away from separating equilibria. This does not mean separation is not important. Among agents who have chosen to be hedge fund managers, it makes little sense for them to reveal, explicitly or implicitly, that they are of type b. However, one can imagine that many agents with even less skill perhaps decided that it was not worth pretending to be type g managers, and thus choose not to become hedge fund managers in the first place. Note also that one can easily relax assumption (5). All that is necessary is to assume that career value is large enough (or $|\bar{r}_2^b - \bar{r}_1^b|$ is small enough) that a type b manager would not choose to reveal his type.

2.2 Reputation updating

Given the structure above, upon observing the investment outcome, r_i, the investor applies Bayes' rule to update his manager's reputation. The manager's reputation concern is made clear in the following lemma.

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

$$\rho_i^* \equiv \frac{\underline{\rho}(1 - p_i^b)}{1 - [(1 - \underline{\rho})p_i^g + \underline{\rho}\ p_i^b]}. \tag{6}$$

Consider a manager in strategy i. If $\rho_0 \geq \rho_i^*$, then the manager can keep the investor's capital regardless of his return. If $\rho_0 < \rho_i^*$, however, then the manager can keep the capital if he succeeds, but not if he fails.

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. 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 and, as we will see later, may distort his investment decision accordingly.

To simplify our later discussions, we set

$$\frac{1-p_1^g}{1-p_1^b} = \frac{1-p_2^g}{1-p_2^b}. \tag{7}$$

That is, the likelihood of a type g manager failure relative to a type b manager failure is the same across both strategies. This implies that a failure in either of the two strategies reduces the reputation by the same amount. Hence, this assumption implies $\rho_1^* = \rho_2^*$, and we will simply use ρ^* to denote both ρ_1^* and ρ_2^*. Intuitively, it means that failure in either strategy is comparably informative about the manager's lack of skill.[6]

2.3 Equilibrium

The equilibrium is defined by the manager's strategy choice, such that the choice solves (4) and the investor expects this choice and updates the manager's reputation according to Bayes' rule. The equilibrium is characterized in the following proposition.

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

$$a = 1 \quad \text{if} \quad \bar{r}_2^g < \bar{r}_1^g + R, \tag{8}$$

$$a = 2 \quad \text{if} \quad \bar{r}_2^g > \bar{r}_1^g + R, \tag{9}$$

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

[6] This simplifying assumption is not crucial for our main results. It does, however, rule out the possibility that the occasional loss from strategy 1 leads to a larger downgrade in reputation. On the other hand, it includes the case where the rare success from strategy 2 has a larger upgrade in reputation. Overall, this simplifying assumption does not necessarily make strategy 2 less (or more) appealing.

1. *if* $\rho_0 < \rho^*$, *then* $R = (p_1^g - p_2^g)V$;

2. *if* $\rho_0 \geq \rho^*$, *then* $R = 0$.

The above proposition describes how the resulting equilibrium changes as a function of the manager's initial reputation, ρ_0, and of the relative attractiveness of the two strategies, $\bar{r}_1^g, \bar{r}_2^g$. As illustrated in (8) and (9), due to reputation concerns, managers do not necessarily choose the strategy with a 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 forgo the alternative strategy that offers an extra expected return up to R. Following Dasgupta and Prat (2006, 2008), we call R the "reputation premium."

This reputation premium varies across the initial reputation level ρ_0. In case 1, the manager has a low initial reputation level, and $\rho_0 < \rho^*$ implies that the manager will be fired if his strategy fails. Sitting on the verge of being fired, the manager has a strong incentive to reduce his chance of failure. 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 reputation premium $R = (p_1^g - p_2^g)V$.

This reputation concern is significantly weakened if the manager's initial reputation level is very high. As shown in case 2, if the manager's initial reputation is higher than ρ^*, then he will not be fired regardless of his performance. The manager then has no reputation concern and simply prefers the more profitable strategy. That is, two strategies are equally attractive if they offer the same expected return, and the reputation premium is zero.

3 The Model

We now consider a dynamic model with T periods, $t = 0, ..., T$. The one-period returns of the two trading strategies are similar to those in Section 2. Specifically, for each period $t = 1, ..., T$, $i = 1, 2$, and $j = g, b$, the strategy return r_i is independent over time and is given by (1). We assume that at $t = 0$, the manager chooses to develop expertise in one of the two strategies and has to stick to the chosen strategy until T. This is, of course, a simplification just to reflect the fact that managers cannot completely change their strategy without incurring any cost.[7] In this dynamic setup, we can endogenize the manager's career value V to reflect the fact that a high reputation keeps the manager's job safe and, more importantly, increases the manager's asset under management. To capture this intuition, we adopt the following simple structure: we assume the manager has two investors. The first investor delegates

$$W_1 = \gamma W, \tag{10}$$

and behaves identically to the investor in Section 2. The second investor always delegates his wealth,

$$W_2 = (1-\gamma)W, \tag{11}$$

to the manager. That is, while the first investor constantly evaluates the quality of his manager and withdraws his capital whenever the manager's reputation falls below $\underline{\rho}$, the second investor is a "die-hard" fan of the manager and always invests with the manager. This simplified structure is meant to capture the idea that the manager can attract a large amount of capital once his reputation rises above $\underline{\rho}$. This is motivated by the empirical evidence of the convex performance-fund flow relation in Chevalier and Ellison (1997). Note also that this assumption includes the example in Section 2 as a special case of $\gamma = 1$.

The manager has an initial reputation of ρ_0. At time $t \geq 1$, after observing the investment return r_i, investors update the manager's reputation according to Bayes' rule:

$$\rho_t \equiv \Pr(g|r_i, \rho_{t-1}) = \frac{\Pr(r_i|g) \times \rho_{t-1}}{\Pr(r_i|g) \times \rho_{t-1} + \Pr(r_i|b) \times (1-\rho_{t-1})}, \tag{12}$$

where ρ_{t-1} is the manager's reputation at time $t-1$, and for $j = g, b$,

$$\Pr(r_i|j) \equiv \begin{cases} p_i^j & \text{if } r_i = r_i^+, \\ 1 - p_i^j & \text{if } r_i = r_i^-. \end{cases} \tag{13}$$

For simplicity, we assume that the investors rebalance every period: withdrawing profits

[7] In an earlier version, we adopted an alternative assumption that the manager can freely switch his strategy every period. The analysis remains similar. One notable difference is that the manager switches his strategy when his reputation level changes, creating large asset relocations and swings in prices even when there is no change in fundamentals.

from the fund or replenishing losses. That is, the manager's assets under management are W if he keeps both investors, and they are $(1-\gamma)W$ if he has only investor 2. Hence, we can denote the total assets under management at time t as $W_t \equiv W_2 + W_1 \times 1_{\rho_t \geq \underline{\rho}}$. This assumption ignores the impact of capital gains and losses on the manager's assets under management. However, our setup does include the main factor that affects the manager's assets under management–namely, the capital flows in and out of the fund. The benefit of this simplifying assumption is that the only state variable in the manager's optimization problem is his reputation level. Removing this assumption complicates the analysis and has no material impact on the main implications below.

The manager's objective can be written as

$$\max_{a \in \{1,2\}} E_0 \left[\sum_{t=1}^{T} \phi W_{t-1} r_t \right], \tag{14}$$

where ϕ $(0 < \phi < 1)$ is the fraction of returns accruing to the manager, and r_t the strategy return at time t. That is, the manager's objective is to choose the strategy to maximize his expected future performance fees.[8] Similar to the case in the static model, the manager's strategy choice at $t = 0$ is summarized in the following proposition.

Proposition 2 *For the economy defined in this section, the manager's choice is given by*

$$a = 1 \quad \text{if} \quad \bar{r}_2^g < \bar{r}_1^g + R, \tag{15}$$

$$a = 2 \quad \text{if} \quad \bar{r}_2^g > \bar{r}_1^g + R, \tag{16}$$

where

$$R \equiv \gamma \frac{\bar{r}_1^g \sum_{t=1}^{T} (\pi_{1,t} - \pi_{2,t})}{T - \gamma \sum_{t=1}^{T} (1 - \pi_{2,t})}, \tag{17}$$

where $\pi_{i,t}$, for $i = 1, 2$ and $t = 1, ..., T$, are constants and are given by (23) in the Appendix.

This proposition clearly demonstrates the impact of reputation concern on the manager's choice. In the case $\gamma = 0$, all the investors are the manager's "die-hard" fans. As shown in equation

[8]Parallel to the model in Section 2, one can also introduce another term, $V(\rho_T)$, into the objective function (14) to capture the intuition that the manager still cares about his reputation when he closes his current fund and moves on to another job. The analysis for this extension is straightforward.

(17), without the threat of capital withdrawal, the manager simply chooses the more profitable strategy, i.e., $R = 0$. Once γ is positive, reputation concern distorts the manager's strategy choice because the manager wants to maximize the current period investment return, as well as his assets under management in the future. Equation (17) further shows that the absolute value of R increases with γ, suggesting that when the fund flow is more sensitive to the manager's reputation, the distortion of the manager's choice is stronger.

As pointed out by Fama (1980), competition and market forces can mitigate the agency problem. The results in Proposition 2, however, demonstrate the limitation of the role of market discipline. In fact, market discipline can exacerbate the agency problem. When there is discipline ($\gamma > 0$), the manager may adopt a less profitable trading strategy precisely because of this discipline. To see the precise impact of reputation concerns more clearly, we turn to the simpler case of $T = 2$ so we can obtain more explicit expressions for reputation premium.

Corollary 1 *In the case of $T = 2$, reputation premium (17) can be simplified into*

$$\begin{aligned}
&\textit{case 1:} \quad R = 0 && \textit{if } \rho_0 \in [\rho^h, 1], && (18)\\
&\textit{case 2:} \quad R = \frac{\gamma \bar{r}_1^g (p_1^g - p_2^g)}{2 - \gamma (1 - p_2^g)} && \textit{if } \rho_0 \in [\underline{\rho}, \rho^h), && (19)\\
&\textit{case 3:} \quad R = \frac{\gamma \bar{r}_1^g (p_1^g - p_2^g)}{2 - \gamma (2 - p_2^g)} && \textit{if } \rho_0 \in [\rho^m, \underline{\rho}), && (20)\\
&\textit{case 4:} \quad R = -\frac{\gamma \bar{r}_1^g p_2^g}{2 - \gamma (2 - p_2^g)} && \textit{if } \rho_0 \in [\rho^l, \rho^m), && (21)\\
&\textit{case 5:} \quad R = 0 && \textit{if } \rho_0 \in [0, \rho^l), && (22)
\end{aligned}$$

where ρ^h, ρ^m, and ρ^l are constants, and $0 < \rho^l < \rho^m < \underline{\rho} < \rho^h < 1$, and are given by equations (24)–(26) in the Appendix.

This corollary illustrates a rich set of implications. As made clear in equations (18)–(22), the impact of reputation concern varies substantially with the manager's initial reputation level. In case 1, the manager's reputation is extremely high, $\rho_0 \in [\rho^h, 1]$. He is not concerned about his reputation because all investors completely trust him and will not withdraw their capital even after poor returns. Hence, the manager will simply choose the more profitable strategy, and the reputation premium is zero.

In case 2, $\rho_0 \in [\underline{\rho}, \rho^h)$, the manager's reputation is high enough to attract capital from the first investor. However, the manager also knows that this investor will withdraw after a poor performance. Anticipating this, the manager finds the nickel-picking strategy 1 appealing, leading to a reputation premium, given by equation (19).

In case 3, the manager's reputation is still lower, $\rho_0 \in [\rho^m, \underline{\rho})$, and he has an even stronger reputation concern. The reason is that, with a low initial reputation, the manager has only the "die-hard" investor's capital under management. Hence, he has little to lose from his current performance and so is more tempted to distort his strategy to attract capital inflow. Strategy 1 is appealing because it has a higher chance of success, and the manager's initial reputation is just slightly below $\underline{\rho}$, one success in strategy 1 is enough to bring his reputation above the threshold and generate large capital inflow.

The manager's reputation level is even lower in case 4, $\rho_0 \in [\rho^l, \rho^m)$, and a success in strategy 1 is not enough to increase his reputation above $\underline{\rho}$. A success in strategy 2, however, is enough to bring the manager's reputation above the threshold and attract large capital inflow. As a result, the manager now has an incentive to avoid strategy 1, leading to a negative reputation premium.[9] That is, strategy 2 is like "swinging for the fences": a success will make the manager a "star," leading to large capital inflow. This strategy might be appealing for a manager whose reputation is low because a success in a nickel-picking strategy won't help him to attract capital. In the final case, $\rho_0 \in [0, \rho^l)$, the manager's reputation is so low that it is hopeless for the manager to try to attract capital inflow. As a result, the manager focuses only on profitability, and the reputation premium is zero.

In summary, the simple model implies a rich set of behaviors. Managers, except those with extremely high or low reputations, adjust their strategy choices according to reputation

[9] It is easy to see 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 (7). 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. Moreover, there may be other reasons that a success in strategy 2 leads to large capital inflow. For example, strategy 2 is like a bet on a small-probability event. Once it succeeds, the profit tends to be very large and may attract large inflows for reasons not modeled here.

concerns. Well-established managers (case 2) find the nickel-picking strategy 1 appealing because it increases the chance for them to keep their investors. Relatively less-established managers (case 3) find strategy 1 even more appealing because they need the final boost of reputation to attract more capital, and they have less to lose currently because their assets under management are small. More junior managers (case 4) may prefer to swing for the fences, choosing strategies that have a small chance of generating spectacular returns. This analysis leads to a number of implications, which we discuss next.

4 Implications

4.1 Popularity of nickel-picking strategies

The above analysis implies the popularity of nickel-picking strategies. If a manager chooses alternative strategies that 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. Moreover, if a manager has a fairly good reputation and a bit more success would help him to attract large capital inflow, he naturally finds nickel-picking strategies appealing because they are more likely to generate profits. As illustrated in Corollary 1, only managers with very low reputations find the nickel-picking strategy unappealing (case 4). Note also that, due to their low reputation, these managers are likely to have less money to start their funds in the first place.

There are plenty of anecdotes suggesting the popularity of nickel-picking strategies. For example, despite repeated warnings of the housing bubble before 2007, few market participants found it appealing to bet on its collapse. Betting on the collapse is the opposite of a nickel-picking strategy, and it is a daunting task 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, e.g., those betting with personal wealth.[10] In the few cases in which hedge fund managers bet against the housing market, there are plenty of detailed stories about them enduring the pressure of capital withdrawal from their investors after initial losses.[11]

While these anecdotes are eye-catching, they might reflect unusual behavior during rare events. Recall that nickel-picking strategies are those that 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.[12]

Note that because these calculations are performed using indices rather than individual fund returns, there is likely 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 correlated and that the skewness in individual funds' return is likely to be

[10]See, e.g., "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.

[11]See, e.g., *The Big Short* by Michael Lewis, 2011; "Trader Made Billions on Subprime," *Wall Street Journal*, January 15, 2008.

[12]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.

even larger than that presented in the table.

4.2 Cross-sectional and time-series 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 star 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 – as in cases 2–4 – might be 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 performance of the industry. 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 increases the popularity of nickel-picking strategies. Moreover, 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 affect managers' strategy choices and the overall performance of the industry.

4.3 Slow-moving capital

A more subtle implication is how a manager's reputation evolves over time. As we will see next, 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 and price fluctuation while there is little or no information about the fundamentals.

These results fit nicely with the empirical evidence documented in Mitchell, Pedersen, and Pulvino (2007). For example, they show that before the end of 2004, convertible 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 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 the phenomenon "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 $t = 0$ (e.g., as in case 2 of Corollary 1), and they choose to invest in the convertible bond arbitrage strategy. After some losses, those managers' reputation level drops below $\underline{\rho}$. This leads to large capital withdrawal from investors, and multi-strategy hedge funds also actively move money away from the disfavored convertible bond strategy, as happened in late 2004 and early 2005. While capital withdrawal after poor performance is relatively well understood, the ensuing extremely slow recovery appears more puzzling. Our model suggests that reputation might be playing an important role. Those fund managers have a hard time raising more capital with their damaged reputation. More importantly, we show next that rebuilding reputation is a very slow process.

This point becomes clear in the following thought experiment: Suppose a manager has a failure in one strategy. How quickly can his reputation recover back to the original level? The answer is given by the following corollary.

Corollary 2 *Define n as the smallest positive integer that satisfies*

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

Then, following a failure in strategy i, it takes n consecutive successes for his reputation to recover back to his original level. Moreover, n weakly increases in p_i^g.

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%. This implies $n = 4$, that is, after a failure in this strategy, it takes four consecutive successes for a manager to rebuild his reputation back to its original level, suggesting that rebuilding reputation is a slow process.

More importantly, note that the corollary also suggests that rebuilding reputation is particularly slow for nickel-picking strategies (those with high p_i^g). Those strategies earn small positive returns most of the time but occasionally lead to big losses. A subtle but natural consequence of this return distribution is that the managers' reputation tends to go up gradually in small steps, but occasionally drops sharply in a big step. Intuitively, by the law of iterated expectations, a manager's reputation is a martingale. Obviously, if a martingale process goes up more often than down, the size of up-moves has to be smaller than the size of down-moves.

In summary, due to reputation concerns, many fund managers find nickel-picking strategies appealing. The consequence of this choice, however, is that one bad performance leads to a big hit to the managers' reputation, and the reputation-rebuilding process tends to be very slow. This fits nicely with the episodes documented in Mitchell, Pedersen, and Pulvino (2007) that after drastic outflow induced by poor performance in a trading strategy, capital becomes slow moving–i.e., reluctant to come back.

4.4 Price impact

The analysis so far abstracts away from fund managers' impact on market prices because the strategy returns are exogenously given. In practice, however, when a large volume of hedge fund capital flows into or out of a given strategy, it is likely to put pressure on the underlying asset prices.[13] To appreciate the price impact, let us conduct the following extension.

Suppose there are N managers and each manager's reputation is a random draw from a uniform distribution on the interval $[\underline{\rho} - \Delta, \underline{\rho} + \Delta]$. That is, the managers' reputation levels are spread evenly over the interval $[\underline{\rho} - \Delta, \underline{\rho} + \Delta]$. The assets under management are W for those above $\underline{\rho}$ and W_2 for those below. For simplicity, we assume the returns of each manager are independent from each other. One can interpret this assumption as investors evaluating managers' performances relative to the benchmark of the industry. To capture the price impact, we assume that the expected return of a strategy for the next period decreases with the amount of capital invested in the strategy. This is to capture 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.

Suppose all N managers have chosen a strategy at $t = 0$. Then, there is a shock to the strategy and everyone suffers a loss at $t = 1$. How do the reputation levels of the managers, the assets under management, and the profitability of the strategy evolve over time? In our simplified model, the answer is completely pinned down by the reputation levels of the group. Figure 1 plots the time series of the fraction of the managers whose reputation is above $\underline{\rho}$. At $t = 0$, the reputation of half of the managers is above $\underline{\rho}$. After the shock at $t = 1$, it becomes less than 10%. That is, around 40% of the managers see their reputation levels drop below $\underline{\rho}$ and suffer large capital withdrawal. The interesting point in the figure is the speed with which managers' reputation recovers. The plot shows that the speed of recovery decreases with the probability of success, p_i^g. That is, for a nickel-picking strategy, which has a high p_i^g, reputation levels recover very slowly. As shown by the solid line, even after 8 periods, only 28% of the managers have reputation above $\underline{\rho}$. In contrast, if the strategy is less like nickel-picking, as shown by the dotted line, reputation recovers more quickly. Almost 42% of the managers' reputation is above $\underline{\rho}$.

The above example suggests that reputation concerns can lead to large swings in capital allocation and asset prices. In particular, following a big shock in performance and the ensuing

[13] Even in the most liquid markets (such as the U.S. treasury markets and stock market), relatively small supply shocks can have a significant impact on asset prices, as documented in Lou, Yan and Zhang (2010).

drastic capital withdrawal, the investment opportunity might become even more profitable. However, fund managers may have a hard time raising capital to exploit it, and capital appears to be slow moving.

5 Discussions

The previous analysis takes the compensation contract as given. A natural question is whether investors and managers can design a different contract to help mitigate the inefficiency (i.e., investing in a less profitable strategy). In the following, we discuss the effects of three contracting mechanisms: lockups, high-powered incentives, and pre-commitment. We find that lockups improve efficiency for some but not all parameter values, while high-powered incentives and pre-commitment are also likely to be of limited effectiveness in the real world.

5.1 Lockup

Suppose investors agree to lock up their capital with a manager for at least t periods, thereby ensuring that the manager's career is safe during the period of the lockup. The manager could therefore have several chances to try the profitable but risky strategy 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, having a lockup can decrease the reputation premium, making managers more willing to take strategy 2 when it offers a higher expected return. For example, the parameter $1-\gamma$ in the model (the fraction of the die-hard investors) can be interpreted as the fraction of the investors constrained by lockup.

By alleviating the career concern, lockups unambiguously improve managers' welfare. However, the same is not always true for the investors, who face a tradeoff between the option of firing their manager and the benefit from the lockup provision—less-distorted investment decisions. Intuitively, one can see that the option value is highest for investors whose manager has a low reputation. In fact, investors prefer to not to have the lockup provision when their manager's reputation ρ is low, or when the return differential between strategies is small. Note that these are precisely the cases when reputation concerns are likely to distort investments.

Lastly, in practice, the lockup period is usually around one year; its impact is hence limited.[14]

5.2 High-powered incentives

In the simple setup analyzed earlier, one can design a contract to induce a separating equilibrium where only type g managers find it attractive to be a money manager, while type b managers prefer to leave the industry and choose a different career. The simplest such contract is to offer a very high reward for success and to combine it with a large penalty for failure. In the static example, for instance, since a type g manager has a higher chance of succeeding than a type b one, we can choose the sizes of the reward and penalty to make the type g manager's expected compensation positive and the type b manager's expected compensation less than $-V$. This implies that only the g-type prefers to be a manager, and the b-type leaves the industry. Of course, such a contract is likely to be impractical in the real world, where managers have limited liability and are risk averse.

5.3 Pre-commitment

In our model, we assume that an investor can find out his manager's strategy ex post. Hence, the investor can eliminate the distortion induced by reputation concerns by committing to fire his manager who chooses the low return strategy, regardless of the outcome ex post. In essence, this mechanism alleviates the problem of reputation concerns by letting investors dictate their managers' strategy.

There are three practical challenges to the implementation of such a mechanism. First of all, this mechanism relies heavily on the credibility of the commitment. Suppose a manager implements the lower return strategy and succeeds. Then, the investor will be tempted to renege on his threat to fire the manager, since any replacement manager would have a strictly lower reputation. Hence, this mechanism is not effective without a credible commitment. Second, the commitment is unlikely to be credible if the investor faces competition: other investors will be more than happy to hire this manager. Third, even if investors can credibly commit, this

[14]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.

mechanism is likely to be less than perfect if the commitment technology is costly, or if it is costly for investors to verify their manager's strategy reliably.

6 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. Our model 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). It 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 because such investors' impact is likely to be amplified by their externalities on other investors. Moreover, our analysis abstracts away from managers' leverage choice. To the extent that the distribution of strategy payoffs is related to leverage, managers' reputation concerns and their use of leverage will be closely linked. This interaction between reputation concerns and leverage choice seems worthy of further analysis.

Appendix

Proof of Lemma 1

Starting from Bayes' rule,

$$\begin{aligned}\rho_1 \equiv \Pr(g|r_i) &= \frac{\Pr(r_i|g) \times \rho_0}{\Pr(r_i|g) \times \rho_0 + \Pr(r_i|b) \times (1-\rho_0)} \\ &= \frac{(1-p_i^g) \times \rho_0}{(1-p_i^g) \times \rho_0 + (1-p_i^b) \times (1-\rho_0)},\end{aligned}$$

where the second equality follows from managers' pooling under (5) in the case where the observed return was low. Substitute $\underline{\rho}$ for ρ_1, and rearrange to solve for ρ_0. This gives (6), 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 focus on type g manager's optimal strategy, since type b managers always mimic. Following the manager's objective (4), the manager is indifferent between the two strategies when

$$\phi W^d \bar{r}_1^g + \Pr(\rho_1 \geq \underline{\rho}|a=1) = \phi W^d \bar{r}_2^g + \Pr(\rho_1 \geq \underline{\rho}|a=2).$$

This implies

$$R = \bar{r}_2^g - \bar{r}_1^g = \frac{\Pr(\rho_1 \geq \underline{\rho}|a=1) - \Pr(\rho_1 \geq \underline{\rho}|a=2)}{\phi W^d}.$$

Note that holding all other parameters unchanged, increasing the return of either strategy will cause the manager to prefer that strategy. Plugging in for the above probabilities that follow from Lemma 1 completes the proof.

Of course, an alternative equilibrium can be supported if one chooses an extreme off-equilibrium belief. For example, if $\bar{r}_1^g < \bar{r}_2^g < \bar{r}_1^g + R$ and $\rho_0 < \rho^*$, the equilibrium in Proposition 1 is that the manager chooses strategy 1. One can construct an alternative equilibrium in which the manager chooses strategy 2, and it can be supported by the off-equilibrium belief that "only a type b manager chooses strategy 1." This equilibrium is not robust in the sense of DeMarzo, Kaniel, and Kremer (2007): Suppose there is a small chance α $(0 < \alpha < 1)$ that the manager chooses his strategy randomly, regardless of his type. Then, in the above example, the strategy 2 is no longer the equilibrium choice since a type g manager would prefer to deviate to strategy 1.

Proof of Proposition 2 and Corollary 1

We solve for the return differential, $R = \bar{r}_2^g - \bar{r}_1^g$, such that a type g manager is indifferent between strategy 1 and strategy 2. Then it immediately follows that holding all other parameters unchanged, increasing the return of either strategy will cause the manager to prefer that strategy.

First define the notation $\pi_{i,t}$, the probability that a type g manager who chose strategy i has reputation $\rho_t \geq \underline{\rho}$ at time t:

$$\pi_{i,t} \equiv \sum_{m=0}^{t} \left(p_{i,m,t} \times 1_{\rho_{i,m,t} \geq \underline{\rho}} \right), \tag{23}$$

where $1_{\rho_{i,m,t} \geq \underline{\rho}}$ is an indicator variable that equals 1 if $\rho_{i,m,t} \geq \underline{\rho}$ and 0 otherwise;

$$\rho_{i,m,t} \equiv \frac{(p_i^g)^m (1-p_i^g)^{(t-m)} \rho_0}{(p_i^g)^m (1-p_i^g)^{(t-m)} \rho_0 + (p_i^b)^m (1-p_i^b)^{(t-m)} (1-\rho_0)}$$

is the manager's reputation after m successes in t periods; and

$$p_{i,m,t} \equiv (p_i^g)^m (1-p_i^g)^{(t-m)} \binom{t}{m}$$

is the probability of achieving reputation $\rho_{i,m,t}$. A type g manager finds the two strategies indifferent if

$$\bar{r}_2^g \phi W \times \left[(1-\gamma)T + \gamma \sum_{t=0}^{T-1} \pi_{2,t} \right] = \bar{r}_1^g \phi W \times \left[(1-\gamma)T + \gamma \sum_{t=0}^{T-1} \pi_{1,t} \right].$$

The above equation leads to (17). Substituting (23) and $T = 2$ into (17), rearranging, we obtain the results in (18)–(22), with

$$\rho^h \equiv \frac{(1-p_1^b)\underline{\rho}}{(1-p_1^b)\underline{\rho} + (1-p_1^g)(1-\underline{\rho})}, \tag{24}$$

$$\rho^m \equiv \frac{p_1^b \underline{\rho}}{p_1^b \underline{\rho} + p_1^g (1-\underline{\rho})}, \tag{25}$$

$$\rho^l \equiv \frac{p_2^b \underline{\rho}}{p_2^b \underline{\rho} + p_2^g (1-\underline{\rho})}. \tag{26}$$

Proof of Corollary 2

It follows from Bayes' rule that $(1-p_i^g)(p_i^g)^k \geq (1-p_i^b)(p_i^b)^k$ is a necessary and sufficient condition for $\rho_{t+k+1} \geq \rho_t$ after one failure and k successes, with equality in one associated with equality in the other. That is, intuitively, if an outcome is equally likely to have come from a type g manager or a type b manager, then the manager's reputation must be unchanged after observing that outcome. Rearranging gives the corollary.

Define m as the solution to

$$\frac{1-p_i^g}{1-p_i^b}\left(\frac{p_i^g}{p_i^b}\right)^m = 1.$$

Then n is the smallest integer that is larger than m. Solving for m, we obtain

$$m = \frac{\mathrm{Log}\left(\frac{1-p_i^b}{1-p_i^g}\right)}{\mathrm{Log}\left(\frac{p_i^g}{p_i^b}\right)}.$$

Differentiating with respect to p_i^g, and simplify, to get

$$\frac{\partial m}{\partial p_i^g} = \frac{X}{(1-p_i^g)p_i^g \mathrm{Log}\left(\frac{p_i^g}{p_i^b}\right)^2},$$

where

$$X = p_g \mathrm{Log}\left(\frac{p_i^g}{p_i^b}\right) - (1-p_i^g)\mathrm{Log}\left(\frac{1-p_i^b}{1-p_i^g}\right).$$

So, the sign of $\frac{\partial m}{\partial p_i^g}$ is the same as the sign of X. Note that

$$\frac{\partial X}{\partial p_i^b} = \frac{1-p_i^g}{1-p_i^b} - \frac{p_i^g}{p_i^b} < 0.$$

That is, X decreases in p_i^b. So, X's infimum is achieved at p_i^b's supremum ($p_i^b = p_i^g$), which is $X = 0$. This implies that $X > 0$ for $p_i^b < p_i^g$. Therefore, m strictly increases in p_i^g, and hence n weakly increases in p_i^g.

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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 1: 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.

Figure 1: Slow Recovery in Reputation.

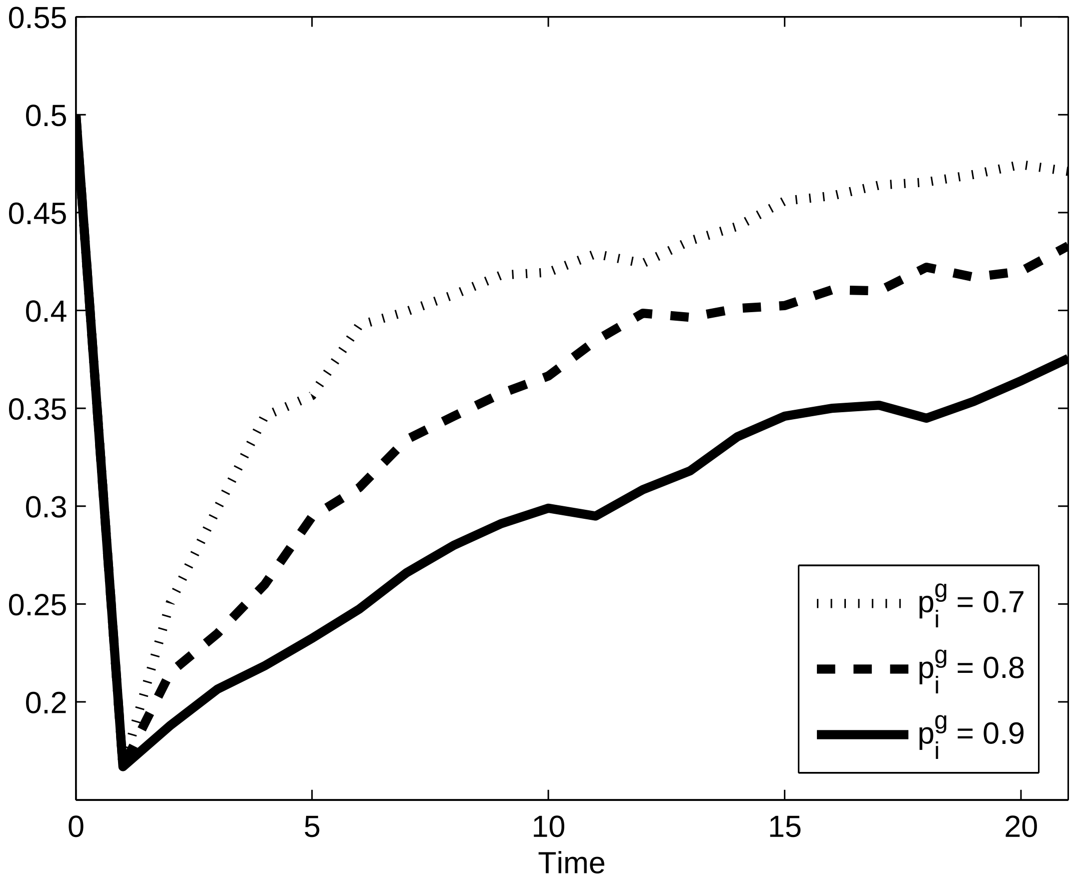

Figure 1: This figure plots the time series of the fraction of managers whose reputation is above $\underline{\rho}$. All managers suffer a loss at $t = 0$. Parameter values: $\underline{\rho} = 0.5, \Delta = 0.25, (1 - p_i^g)/(1 - p_i^b) = 0.5, N = 2,000$.