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DELEGATED ASSET MANAGEMENT, INVESTMENT MANDATES, AND CAPITAL IMMOBILITY

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ABSTRACT

This paper develops a model to explain the widely used investment mandates in the institutional asset management industry based on two insights: First, giving a manager more investment flexibility weakens the link between fund performance and his effort in the designated market, and thus increases agency cost. Second, the presence of outside assets with negatively skewed returns can further increase the agency cost if the manager is incentivized to pursue outside opportunities. These effects motivate narrow mandates and tight tracking error constraints to most fund managers except those with exceptional talents. Our model sheds light on capital immobility and market segmentation that are widely observed in financial markets, and highlights important effects of negatively skewed risk on institutional incentive structures.

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1 Introduction

The institutional asset management industry has experienced rapid growth in the last two decades. In 2008 the global asset management industry managed a total of around $90 trillion, through various types of funds, such as pension funds, mutual funds, insurance funds, hedge funds, private equity funds, and exchange traded funds. This sheer size already makes institutional investors a key player in the financial markets. Their distinctive institutional incentive structures also make their preferences and investment characteristics very different from those of individual investors. The Bank for International Settlements initiated a working group on incentive structures in the institutional asset management industry. By interviewing more than 100 industry practitioners from 14 countries, the working group identified several general trends in this industry. One of them is the use of more stringent investment mandates, i.e., "*a tiering and narrowing of investment mandates, enhanced by an increasing emphasis on relative performance measurement, narrowing tracking errors and more pervasive use of other investment constraints, such as limits on investing in specific securities or diversification rules.*" (BIS report, 2003.) This trend is puzzling—from an investment efficiency perspective—because stringent mandates limit the fund managers' ability to take advantage of investment opportunities outside their mandates.[1] As we will discuss later, this trend can have important implications for asset market dynamics.

What motivates the use of stringent investment mandates? After all, a typical expertise related argument implies that managers with superior expertise in certain markets will voluntarily choose to invest in their specialized markets without the aid of mandates. In practice, investment mandates are often reflected and enforced by constraints on funds' tracking errors of designated indices. What determines the cross-sectional difference in funds' tracking error tolerance?[2] Which managers and to what extent should be incentivized to pursue outside investment opportunities? How should they be compensated? In this paper, we provide an agency-based model to address these questions. Our model also incorporates negatively skewed risk, a widely recognized challenge to financial institutions due to the limited liability of traders and fund managers, to analyze its effects on funds' incentive structures and investment strategies.

[1] Jame (2010) finds evidence that trades made by pension funds in non-S&P 500 stocks significantly outperform their trades in S&P 500 stocks, and that tracking error constraints imposed on pension funds weaken the performance of their trades by roughly 30 basis points per year.

[2] An argument based on investors' demands for specialized funds can explain the existence of investment mandates that accompany specialized funds, but cannot explain the varying degree of tracking error constraints across funds.

The asset management industry has a complex incentive structure. Financial service companies, such as Fidelity and TIAA-CREF, offer families of investment funds for investors to choose from and typically charge a fixed fee based on asset under management. New fund inflows after superb fund performance provide implicit incentives for the fund family to hire a capable fund manager (e.g., Chevalier and Ellison (1997), and Brown, Harlow, and Starks (2006)). An equally important aspect which has not received much attention in the empirical literature, is that the majority part of individual fund managers' compensation is a relative performance based bonus (BIS report 2003).[3] These observations suggest that the asset management industry builds on two layers of implicit and explicit incentives: one layer of implicit incentives from investors to fund families, and another layer of explicit incentives from fund families to fund managers. The literature has developed distinctive approaches to analyze the effects of these implicit and explicit incentives. The career-concern framework has been widely adopted to analyze the implicit incentives, while the optimal contracting approach has been used to study the explicit incentives.[4]

Our model adopts the optimal contracting approach to focus on explicit incentives of individual fund managers. This approach allows us to derive investment mandates, which are usually explicitly stated in fund prospectuses and enforced by managers' compensation contracts. Specifically, we analyze a model with a risk neutral principal delegating capital to a risk averse fund manager. In light of the two-layered incentive structure discussed above, one can interpret the principal as a fund family, which hires the manager to manage one of its funds. Different from the aforementioned models, our model allows the manager to face investment opportunities in several markets instead of one. The manager has a primary market. While his expertise endows him some private information about the asset return in this market, he can improve the precision of his information by exerting unobservable costly effort. Thus, the principal needs to incentivize the manager to work. In addition, the manager's expertise also gives him a free signal about the asset return in another market, whose identity is known only to the manager. This free signal is not as precise as his signal

[3] "*The size of the bonus component in individual asset managers' compensation varies considerably across countries. However, at least in some countries, there seems to be a general trend towards a higher share of variable compensation in total pay over recent years.... US managers can earn average bonuses of 100% and higher. In the United Kingdom, where the median fund manager will get a bonus of about 100%, exceptional asset managers can earn as much as six times their base salary in the form of bonuses.*" (the BIS report, 2003, page 23)

[4] For models building on the career-concern approach, see Berk and Green (2004), Dasgupta and Prat (2008), Vayanos and Woolley (2008), Malliaris and Yan (2009), Makarov and Plantin (2010), Guerrieri and Kondor (2012), and Kaniel and Kondor (2012)); for models using the optimal contracting approach, see Bhattacharya and Pfleiderer (1985), Heinkel and Stoughton (1994), Ou-Yang (2003), Palomino and Prat (2003), Cadenillas, Cvitanic, and Zapatero (2007), and Dybvig, Farnsworth, and Carpenter (2010).

about the primary market, but is nevertheless useful.

We deviate from a commonly used framework (e.g., Bhattacharya and Pfleiderer (1985) and Dybvig, Farnsworth, and Carpenter (2010)), in which the principal incentivizes the manager to acquire information and truthfully report the information to the principal, who then makes investment decisions based on the reported information. Our model builds on the premise that the principal is unable to execute the investment decisions. Instead, the manager is responsible for not only acquiring information but also making investment decisions, consistent with the common practice in the money management industry. And, as only the manager can implement the investment decisions, we assume further that the incentive contract cannot be contingent upon the manager's investment positions.[5] Under this setting, the principal needs to motivate the manager not only to exert effort in acquiring information about the primary market, but also to make efficient investment choices to take advantage of his information about the primary market as well as the secondary market. We are particularly interested in analyzing the joint implications of these two dimensions on the optimal incentive contract and the resulting investment efficiency.

A key insight of our model is that there is a trade-off between ex post investment efficiency and ex ante incentive provision efficiency. Allowing the manager to take advantage of outside opportunities when he fails to find a good opportunity in the primary market is ex post efficient, but implementing this efficient strategy weakens the link between the fund performance and his unobservable effort in the primary market. This is because the manager can generate good performance either by effort in the primary market or by random luck (an opportunity unrelated to effort) from outside. In the language of Holmstrom (1979), implementing the efficient investment strategy reduces the ex ante incentive provision efficiency by making benchmarking more difficult.

Building on this trade-off, our model shows that it can be optimal to confine the manager in his primary market depending on his cost of effort and outside investment opportunities. Intuitively, this holds true if his cost of effort is sufficiently high or if his free outside opportunities are only modest. Although the principal cannot directly observe the manager's investment position, he can implement such a strategy by imposing a tight limit on the manager's tracking error of the primary market return. More precisely, he can prevent the

[5] In practice, a fund manager can obscure his positions through complex financial contracts and thus to game any compensation scheme that bases upon his positions. The scandals of rogue traders, such as Nick Leeson of the bankrupted British bank Barings and Jerome Kerviel of French bank Societe Generale, vividly demonstrated that they were able to hide their positions from their supervisors for prolonged periods. These observations motivate us to consider incentive contracts based only on the fund performance and the primary market return.

manager from seeking any outside opportunity by penalizing the manager's good performance if it deviates substantially away from the benchmark primary market return. On the other hand, if the manager's effort cost is sufficiently low or if his outside opportunities are abundant, it is optimal to incentivize him to pursue opportunities both inside and outside the primary market by granting a sufficient tolerance on tracking error and by rewarding him for beating the primary market.

The incentive to pursue outside opportunities can also induce the manager to seek unwarranted negatively skewed risk even when he finds no good opportunity. As widely recognized by academia and policy makers, active risk seeking is a severe problem in designing institutional risk management system and incentive structure.[6] Lowenstein (2000) attributes the financial crisis of the hedge fund Long Term Capital Management to its negatively skewed trading strategy, which gives steady positive returns for a prolonged period only to be followed by a loss of all of the previous gains and almost all of its capital. Rajan (2010) and Acharya, Cooley, and Richardson (2010) highlight seeking of tail risk by many financial firms such as AIG and Lehman Brothers as a key contributing factor to the recent financial crisis.

We incorporate a market whose return has an unattractive mean but a negative skewness, i.e., it gives a modest positive return most of the time but a large negative return once in a while. This market is attractive to the manager because he gets compensated for the positive return with a high probability, and leaves the principal to bear the huge loss due to the manager's limited liability. To prevent the manager from seeking this unwarranted risk, the optimal contract in our model will compensate him even if his performance is inferior but the bad performance can be traced to the poor return in his primary market, in order to raises the manager's opportunity cost of seeking the skewed risk.[7] Through this payment and the necessary increases in other payments to offset its negative effect in motivating effort, the presence of negatively skewed risk substantially increases the agency cost.[8] As a result,

[6]For example, such strategies can be selling out-of-money options and under-writing of credit default swap contracts (CDS). These strategies allow an institution to pocket steady cash flows until a large payout caused by the options maturing in the money or defaults of the bonds covered by the CDS contracts.

[7]Malliaris and Yan (2009) and Makarov and Plantin (2010) analyze fund managers' risk-seeking incentives driven by convex fund flow by using career-concern models. The career-concern models are not convenient for analyzing investors' active deterrence of managers' risk seeking because investors are typically passive in these models. In contrast, our model shows that the incentive to seek negatively skewed risk is an inherent by-product of incentivizing fund managers to pursue profitable opportunities, and deterring such risk seeking may require inducing them to use suboptimal investment strategies.

[8]The mechanism of a negatively skewed risk differ from that of the standard volatility risk in delegated asset management (e.g., Ou-Yang (2003), Palomino and Prat (2003), and Cadenillas, Cvitanic, and Zapatero (2007)). These papers typically find that pay for performance is still useful even when fund managers can choose return volatility. In our model, incentive compensation on the primary market itself triggers active seeking of negatively skewed risk outside the primary market, which motivates the use of narrow investment

only managers with exceptional talents can have broad investment mandates.

Taken together, our model provides an agency-based explanation for funds with narrow investment mandates, together with a set of testable implications for varying degrees of investment flexibility across funds. For example, funds tend to face more stringent investment mandates when their managers have lower ability or when they work in more obscure markets that are difficult to analyze. In light of the easier accessibility of negatively skewed risk in the increasingly complex financial markets, our model also explains the aforementioned trend of narrowing investment mandates in the delegated asset management industry.

The widely used narrow investment mandates can have important implications for asset market dynamics. Duffie (2010) highlights capital immobility, i.e., capital often fails to flow to liquidity distressed markets that offer profitable opportunities, as an important factor in understanding asset market liquidity. According to our model, once investors distribute their capital into different market segments through institutionally managed funds, agency considerations constrain most fund managers from moving capital into other liquidity distressed markets. Instead, the strategic decisions of allocating capital across different market segments are often left to the less informed investors themselves. As a result, the flow of capital is likely to be delayed. This explanation of capital immobility based on institutional constraints at the *originating* end of capital flow is distinct from the other explanations based on information barriers about asset fundamentals at the *receiving* end.

Narrow investment mandates can also help explain the de facto segmentation of various asset markets from the broad financial markets in the absence of explicit regulatory and physical constraints on investment. Collin-Dufresne, Goldstein, and Martin (2001), Gabaix, Krishnamurthy, and Vigneron (2007), Garleanu, Pedersen, and Poteshman (2009), and Bekaert et al. (2008) provide evidence of risk premia for market-specific risk factors in the corporate bond market, mortgage-backed securities market, S&P 500 index option market, and emerging stock markets. These findings are broadly consistent with our model in the sense that investors heavily rely on professional fund managers to invest in these markets and agency considerations can motivate narrow mandates on the fund managers. As a result, they are exposed to market specific risk. With fund managers likely being the marginal investor, these markets can exhibit premia for market specific risks and thus de facto segmentation.

The literature has recognized the importance of restrictions on investment strategies in motivating fund managers' efforts. Admati and Pfleiferer (1997) point out that in the absence

mandates.

of portfolio restrictions, a manager can use portfolio choice to offset the incentive intended by his compensation contract. By using a setting whereby the principal can directly observe and contract on the fund manager's investment positions, Dybvig, Farnsworth, and Carpenter (2010) show that imposing portfolio restrictions can improve the efficiency of incentive provision. Our model adopts a more general setting in which the principal cannot observe the manager's investment positions, and derives the optimal incentive contract that relies on penalties against tracking errors to enforce any intended investment strategy. This setting allows us to highlight the conflict between incentive efficiency and investment efficiency. This conflict also differentiates our model from Bhattacharya and Pfleiderer (1985), who show that penalties against tracking errors can motivate a fund manager to truthfully report his information to his principal.

Our paper adds to the literature on effects of agency frictions on financial market inefficiency. Shleifer and Vishny (1997) and Stein (2005) focus on agency risk in arbitrage trading—fund managers are reluctant to take on arbitrage positions because if asset prices deviate further away from fundamentals in the future, investors will withdraw money and thus causes forced liquidation. In contrast, our paper emphasizes that agency frictions can lead to narrow investment mandates, which limit fund managers' ability to take advantage of profitable opportunities outside their mandates.

The paper is organized as follows. We present a basic model in Section 2. Section 3 extends the model to incorporate negatively skewed risk, and Section 4 discusses the model implications. We conclude in Section 5. Appendix A provides technical proofs, and Appendix B presents an alternative model setting to demonstrate robustness of the basic model presented in the main text.

2 The Basic Model

2.1 Setup

We consider a single-period principal-agent model where a risk-neutral principal delegates capital to a risk-averse agent.[9] As we discussed before, the asset management industry has a two-layered incentive structure with fund families charging investors fixed management

[9] Risk neutral principal is interested in maximizing expected fund return, and this assumption, by ruling out various hedging and diversification needs, allows us to focus on agency frictions only. See Massa (2003) and Mamaysky and Spiegel (2002) for studies of how heterogeneity among individual investors in terms of investment horizon and risk preferences can motivate mutual fund families to offer funds specializing in different markets or strategies.

fees while compensating individual fund managers based on fund performance. We focus on the explicit incentives of individual fund managers who directly make investment decisions. Thus, we interpret the principal-agent relationship as a fund family (the principal) hiring a fund manager (the agent) to manage one of its funds.

The manager's utility function over consumption $U(\cdot)$ satisfies $U(0) = 0$, $U'(\cdot) > 0$, and $U''(\cdot) < 0$. Throughout we focus on the specification that

$$U(c) = c^{1-\alpha},\ \alpha \in (0,1). \tag{1}$$

The principal hires the manager to actively invest his money in a primary market, which we denote by market A. We can broadly interpret this market as a specific market sector, such as the treasury bond market, the mortgage bond market, the U.S. stock market, or a regional stock market. We assume for simplicity that the return from this market can only take two possible values, a positive value r or a negative one $-r$, with equal probability:

$$\widetilde{r}_A = \begin{cases} r & \text{with probability } 0.5 \\ -r & \text{with probability } 0.5 \end{cases}. \tag{2}$$

The manager—who possesses certain expertise that normal investors lack—obtains a *private* signal s_A regarding the likelihood of the market going up or down. The signal takes two possible values 1 or -1. If the return is positive (or negative), the signal is more likely to take the value 1 (or -1):

$$\Pr(s_A = 1 \,|\widetilde{r}_A = r) = \Pr(s_A = -1 \,|\widetilde{r}_A = -r) = 0.5 + \Delta_A + \theta. \tag{3}$$

The term $\Delta_A + \theta > 0$ measures the precision of the signal s_A in revealing the return in market A. There are two components in the signal precision: the first part Δ_A captures the manager's knowledge about the market without any effort on the job, while the second part θ represents his effort in acquiring additional information. The effort θ takes binary values, 0 and e, corresponding to "shirking" and "working" respectively. By working hard (e.g., conducting a thorough analysis), the manager improves the signal precision by e. We impose $\Delta_A + e \leq 0.5$ to make the probability meaningful. To differentiate the precision of the signal with and without the manager's effort, we denote s_A^e as the signal with effort and s_A^0 as the signal without effort.

The effort incurs a private (utility) cost k to the manager and is unobservable to the principal. For simplicity, we also assume that the manager exerts effort before he receives any signal.[10] We assume that the manager has an additive utility function over consumption and effort:

$$\overline{U}(c,\theta) = U(c) - \frac{k}{e}\theta, \text{ where } \theta \in \{0, e\}.$$

The fund has one unit of initial capital. To deliver the key insight without getting into unnecessary complications, we simplify the manager's investment choices. First, the manager cannot short sell any asset and cannot borrow either.[11] Second, he always invests all of the fund in one asset: either in market A, the risk free asset, or something else.[12] We normalize the return of the risk-free asset to be zero. Then if he observes a positive signal on market A, the expected return is positive and he will invest the fund in market A; if he observes a negative signal, then he should stay out of market A. But, should he then invest the fund in the risk-free asset or something else? In reality, a fund manager often has expertise beyond his primary market. An important question faced by every fund is whether the manager should be incentivized to pursue outside opportunities when the primary market lacks a good one.

We capture this idea by assuming that the manager can access a set of outside markets. These markets have independently and identically distributed returns with the same binomial distribution as market A. Before the manager makes his investment decision, he also receives a free signal about one of these markets, which we denote by market B. This market is randomly drawn from the pool of outside markets. Neither can the principal observe the signal, nor which market the signal is about. The precision of the manager's free signal on market B is $\Delta_B \in (0, 1/2)$, i.e.,

$$\Pr(s_B = 1 \,|\, \widetilde{r}_B = r) = \Pr(s_B = -1 \,|\, \widetilde{r}_B = -r) = 0.5 + \Delta_B. \tag{4}$$

We also assume that $\Delta_B \leq \Delta_A$, i.e., the manager is better informed about his primary market.

Denote the manager's investment choice by $x \equiv \{x_A,\ x_B,\ x_0\}$, where $x_i \in \{0, 1\}$ indicates the manager's investment position in market i with $i \in \{A, B\}$, and $x_0 \in \{0, 1\}$ is his position in the risk free asset. The borrowing constraint requires that $x_A + x_B + x_0 = 1$. We denote the set of all feasible investment choices by $X = \{x\}$. The fund's return $\widetilde{r}_F$ can take three possible values, i.e., $\widetilde{r}_F \in \{r, 0, -r\}$.

[10] We rule out the possibility that the manager makes his effort choice after he observes a free signal about the market. Such a sequential setup complicates the analysis, but does not add much to the economic insight.

[11] Almazan et al. (2004) document that many mutual funds restrict short selling and leverages.

[12] We discuss the robustness issues related to these simplifying assumption in Section 2.5.

2.2 Optimal Contracting

2.2.1 Incentive Contract

The principal writes a compensation contract to induce effort and a certain investment strategy from the manager. For efficient incentive provision, benchmarking the manager's performance $\widetilde{r}_F$ to his primary market return $\widetilde{r}_A$ (i.e., using relative performance evaluation) is beneficial. It would be useful to incorporate the return of market B. But this is not feasible because market B is randomly drawn from a set of outside markets and the principal does not observe its identity. Thus, we focus on incentive contracts based on the fund performance and the primary market return.[13]

Furthermore, we make a realistic assumption that the incentive contract cannot be contingent upon the fund's investment position. Contracting on fund positions is unrealistic for several reasons. First, it is difficult to find a single measure to summarize the investment positions taken by a real-life fund, which typically holds many positions with different characteristics. Second, while fund families are better monitors of fund managers than investors (e.g., Gervais, Lynch, and Musto (2005)), it is still infeasible for a fund family to continuously monitor each individual investment position of its funds. If reporting of fund positions can only take place at discrete intervals, it will induce window dressing by fund managers to game the reporting system, invalidating the incentive intended by the compensation contract that is based on the reporting. Finally, it is also possible for a fund manager to obscure his positions through complex financial contracts, in order to game any compensation scheme that is based on his positions. In fact, the scandals of rogue traders such as Nick Leeson of the bankrupted British bank Barings and Jerome Kerviel of French bank Societe Generale vividly demonstrated that they were able to hide their true positions from their supervisors for prolonged periods.[14]

[13] In an earlier version of this paper, we have allowed the principal to observe the identity of market B and therefore to write the incentive contract based on the return of market B as well. The key results of our paper remain similar.

Besides, we can further show that *peer evaluation,* i.e., basing one manager's compensation on his relative performance to other funds trading in the same market, cannot help in optimal contracting. The reason is simple: In our model, *conditional on the true state of the primary market return,* the signals are independent across managers. Thus, if the contract incorporates the realized market returns, it has already used the best information for relative performance evaluation (one can formally show this result using the sufficient statistics argument in Holmstrom (1979)).

[14] Also note that while many mutual funds explicitly impose various restrictions on investment positions such as short sales, use of leverages, and investing in derivatives, the enforcements of these restrictions often rely on random auditing and ex post penalties of the funds' advisors and the SEC, e.g., Almazan, et al. (2004, footnote 2). This confirms the difficulty for fund investors to observe fund positions in practice and the potential challenge in enforcing investment restrictions. Under the premise that investment positions are not observable to the principal, our model not only justifies investment mandates but also derives penalties

Thus, an incentive contract Π is a mapping from the information set Ω generated by $\widetilde{r}_F$ and $\widetilde{r}_A$ to non-negative payments to the manager:

$$\Pi : \Omega \equiv \{u, 0, d\} \times \{u, d\} \to \mathbb{R}_{+}.$$

We rule out negative wages to the manager due to limited liability.[15] The fund return can take three possible values: u (up with a return of r), 0, or d (down with a return of $\square r$). The return of market A can take two possible values, u (up) or d (down). There are 6 possible outcomes. Therefore, the contract only needs to specify 6 contingent payments. Denote $\omega = \binom{\widetilde{r}_F}{\widetilde{r}_A} \in \Omega$ as a possible outcome. It is easier to work with the payment in terms of the manager's utility (π_ω) than in terms of dollars (c_ω), where $\pi_\omega = U(c_\omega)$. We write the contract as

$$\Pi = \left\{\pi_u^u,\ \pi_u^0,\ \pi_u^d,\ \pi_d^u,\ \pi_d^0,\ \pi_d^d\right\}. \tag{5}$$

For instance, π_d^u is the manager's utility when the primary market is down but the fund return is up. Then, $c_d^u = U^{\square 1}(\pi_d^u)$ is the cost of compensating the manager for this outcome.

2.2.2 Contracting Problem

For a given contract $\Pi = \{\pi_\omega\}$, the fund manager maximizes his expected utility by first making his optimal effort and then investment choices based on the signals he receives:

$$\max_{\theta \in \{0,e\},\ x \in X} \quad \sum\nolimits_{\omega \in \Omega} p_\omega(\theta, x)\, \pi_\omega \,\square\, \frac{k}{e}\theta,$$

where p_ω is the probability of outcome ω. The manager's effort and investment choices θ and x determine the outcome probability $\{p_\omega\}$. We write $\theta^*(\Pi)$ and $x^*(\Pi)$ as the manager's optimal effort and investment choices, respectively, in response to a given contract Π.

By using different incentive contracts, the principal can induce different investment choices from the manager. When the manager's effort cost is sufficiently low, the first best combination of effort and investment strategies is that the manager exerts effort in the primary market and then follows a so called "two-tiered" investment strategy, as shown in Table 1: If the manager receives a positive signal about the primary market A, he will invest the fund capital in it; if not, he will invest in market B if his free signal about market B

against tracking errors as an enforcement mechanism for investment mandates.

[15] We assume that the manager is both risk averse and protected by limited liability. If we were assuming a risk neutral manager, then limited liability would have generated a non-zero agency cost but the agency cost would not be affected by efficiency of benchmarking in implementing different investment strategies. The reason is that with risk neutral managers, it is optimal for the principal to shift all positive rewards to one good outcome (across two investment strategies, say $\binom{0}{d}$) where the manager's investment strategy is identifiable. This gives rise to the same agency cost across different investment strategies.

indicates a good opportunity; finally, he will invest in the risk-free asset if his signal about both markets A and B are negative. This strategy instructs the manager to take advantage of opportunities outside his primary market. Alternatively, the fund can also implement a "single-market" strategy, as shown in Table 1: The manager will invest in the primary market if his signal on the market is favorable and otherwise put the fund capital in the risk-free asset. Relative to the two-tiered strategy, this strategy requires the same effort cost but forgoes a valuable investment opportunity outside the primary market. As we will show later, this seemingly inferior strategy dominates the two-tiered strategy under certain conditions because of its more efficient incentive provision.[16]

Table 1. Investment Strategies: Single-market versus Two-tiered strategies

Signal realizations	$s_A^e = s_B^e = 1$	$s_A^e = 1, s_B^e = -1$	$s_A^e = -1, s_B^e = 1$	$s_A^e = s_B^e = -1$
Single-market	market A	market A	risk-free asset	risk-free asset
Two-tiered	market A	market A	market B	risk-free asset

As the principal cannot directly observe the manager's investment position, he has to rely on the incentive contract to induce the manager to implement any intended strategy. Put differently, when the principal finds it optimal to use the single-market strategy, he cannot just tell the manager not to invest outside the primary market. In order to enforce this narrow investment mandate, the principal needs a set of detection and penalty mechanisms for preventing potential violation. In our model, the principal can use the fund's tracking error relative to the primary market return to imperfectly detect the manager's deviation from investing in the primary market. By penalizing the manager for a large tracking error, the principal can prevent such a deviation.

The manager has a reservation utility of $\underline{U}$, which represents his forgone outside opportunity cost by managing this fund. The participation constraint requires that:

$$\sum\nolimits_{\omega\in\Omega} p_\omega \left(\theta^* \left(\Pi\right), x^* \left(\Pi\right)\right) \pi_\omega - \frac{k}{e}\theta^* \left(\Pi\right) \geq \underline{U}.$$

Because of limited liability, the manager earns some positive rent in our model, and for

[16] In an earlier draft of the paper, we have also considered a symmetric setting, in which markets A and B are ex ante symmetric to the manager in the sense that his endowed signals about the two markets have the same precision and both can be improved by his personal effort. This symmetric setting allows us to evaluate a so-called combined-market strategy, according to which the manager seeks to find the best opportunity in these markets by exerting effort to improve his signals about both markets. We show that this strategy is desirable if the manager's cost of effort is sufficiently low—lower than the level derived for the optimality of the two-tiered strategy. As this analysis substantially complicates the presentation but adds little additional insight, we choose to leave it out of the paper and instead focus on the comparison between the single-market and two-tiered strategies.

simplicity throughout this paper we assume that $\underline{U}$ is sufficiently small so that the manager's participation constraint is not binding.

The principal's payoff from outcome ω is the portfolio return minus the compensation cost:

$$W_\omega = 1 + \widetilde{r}_F(\omega) - U^{-1}(\pi_\omega). \tag{6}$$

The principal maximizes the expected payoff from the fund by choosing an optimal incentive contract, i.e.,

$$V = \max_{\Pi} \sum\nolimits_{\omega\in\Omega} p_\omega(\theta^*(\Pi), x^*(\Pi))\, W_\omega,$$

subject to the manager's participation and incentive compatibility constraints.

We can further decompose the principal's expected payoff into two components:

$$V = \sum\nolimits_{\omega\in\Omega} p_\omega(1 + \widetilde{r}_F(\omega)) - \sum\nolimits_{\omega\in\Omega} p_\omega U^{-1}(\pi_\omega), \tag{7}$$

where the first part is the expected fund return, which is determined by the manager's effort and investment strategy; and the second part is the expected cost of compensating the fund manager. This decomposition suggests the following two-step method to solve for the optimal contract: First, find the least costly contract to implement each of the two effort and investment strategies; then, compare these least costly contracts to determine the optimal contract that offers the highest expected net payoff to the principal.

2.3 Single-market Strategy

We start with analyzing the least costly contract for implementing a single market strategy in market A, as indicated in Table 1. The contract induces the following effort and investment choices from the fund manager: The manager exerts effort only in market A; after receiving the signal s_A^e, he invests all the fund capital in market A if the signal is positive, and invests in the risk free asset otherwise, regardless of his signal s_B about opportunities outside the primary market. Note that there is an opportunity loss when the manager's signals suggest that the primary market lacks a good investment opportunity while another market, market B, offers a good one ($s_A^e = -1, s_B = 1$).

2.3.1 Incentive Compatibility

The fund manager has two unobservable actions: exerting effort to obtain a precise signal and making the investment choice. In contrast to the costly effort on information acquisition, the investment choice per se does not involve any personal cost, and the incentive compatibility constraint regarding the investment choice is slack (which we will verify later) when implementing the single-market strategy. Here, we discuss the manager's incentive compatibility constraint regarding his effort choice. Taking the manager's investment choice as given, his expected utility from exerting effort on acquiring a more precise signal about market A is:[17]

$$\begin{aligned} & \mathbb{E}\left[\overline{U}\left(c,\theta\right)\left|\text{exerting effort and obtain } s_A^e\right.\right] \\ = \; & 0.5\left[\left(0.5+\Delta_A+e\right)\pi_u^u+\left(0.5-\Delta_A-e\right)\pi_u^0+\left(0.5+\Delta_A+e\right)\pi_d^0+\left(0.5-\Delta_A-e\right)\pi_d^d\right]-k. \end{aligned} \tag{8}$$

Take π_u^u for example. The probability of the outcome $\binom{\widetilde{r}_F}{\widetilde{r}_A}=\binom{u}{u}$ is the probability of state $\widetilde{r}_A=u$ (which is 0.5), multiplied by the probability of the manager receiving a positive signal $s_A^e=1$ conditional on $\widetilde{r}_A=u$ and the manager exerting effort (which is $0.5+\Delta_A+e$). Similarly, the manager's expected utility from shirking is:

$$\begin{aligned} & \mathbb{E}\left[\overline{U}\left(c,\theta\right)\left|\text{shirking with } s_A^0\right.\right] \\ = \; & 0.5\left[\left(0.5+\Delta_A\right)\pi_u^u+\left(0.5-\Delta_A\right)\pi_u^0+\left(0.5+\Delta_A\right)\pi_d^0+\left(0.5-\Delta_A\right)\pi_d^d\right]. \end{aligned} \tag{9}$$

Therefore, the manager's incentive compatibility constraint regarding exerting effort requires that the value of (8) is no less than that of (9), i.e.,

$$0.5\left(e\pi_u^u-e\pi_u^0+e\pi_d^0-e\pi_d^d\right)\geq k. \tag{10}$$

In (10), the coefficient of each utility term in the bracket gives the manager's incentive differential between "shirking" and "working" for a particular outcome ω. For instance, consider π_u^u. By working, the probability of getting π_u^u is $\left(0.5+\Delta_A+e\right)/2$, while by shirking, the probability becomes $\left(0.5+\Delta_A\right)/2$. The difference between these two probabilities is exactly the coefficient $0.5e$ in front of π_u^u in condition (10). The higher this coefficient, the more effective the payment π_u^u in motivating the manager to exert effort. We also call this coefficient the incentive leverage of the payment.

2.3.2 The Least Costly Contract

The least costly contract for implementing the single market strategy is determined by

$$\begin{aligned} \min_{\left\{\pi_u^u,\pi_u^0,\pi_d^0,\pi_d^d\right\}\in\mathbb{R}_+^4} \sum p_\omega U^{-1}\left(\pi_\omega\right) \;=\; & 0.5\left[\left(0.5+\Delta_A+e\right)U^{-1}\left(\pi_u^u\right)+\left(0.5-\Delta_A-e\right)U^{-1}\left(\pi_u^0\right)\right. \\ & \left.+\left(0.5+\Delta_A+e\right)U^{-1}\left(\pi_d^0\right)+\left(0.5-\Delta_A-e\right)U^{-1}\left(\pi_d^d\right)\right], \end{aligned}$$

[17] In implementing the single-market strategy, the two outcomes $\binom{d}{u}$ and $\binom{u}{d}$ are off equilibrium.

subject to the incentive compatibility constraint in (10), which is binding in the solution.

In (10), two outcomes $\binom{0}{u}$ and $\binom{d}{d}$, which represent poor performance relative to market A, have negative incentive leverages. Any payment to the manager for these outcomes is a reward for failure and thus should be minimized to zero (i.e., $\pi_u^0 = \pi_d^d = 0$). On the other hand, π_u^u and π_d^0 represent rewards for good performance in outcomes $\binom{u}{u}$ and $\binom{0}{d}$. Using the standard Lagrange method, the first order conditions provide that

$$U'\left[U^{-1}\left(\pi_u^u\right)\right] = U'\left[U^{-1}\left(\pi_d^0\right)\right] = \frac{(0.5 + \Delta_A + e)}{\lambda e}, \tag{11}$$

where λ is the Lagrange multiplier for the incentive compatibility constraint in (10). Combining this result with (10), we have $\pi_u^u = \pi_d^0 = \frac{k}{e}$.

We also need to specify payments for two off-equilibrium outcomes $\binom{d}{u}$ and $\binom{u}{d}$ to prevent the manager from investing in the secondary market B:

$$\pi_u^d = \pi_d^u = 0.$$

We verify in Appendix A.1 that under these terms, the manager will never deviate to invest in market B. The following proposition summarizes the contract derived above.

Proposition 1 *The least costly contract for implementing the single market strategy uses the following payments:*

$$\begin{cases} \pi_u^u = \pi_d^0 = k/e, \\ \pi_u^0 = \pi_u^d = \pi_d^d = \pi_d^u = 0. \end{cases} \tag{12}$$

The principal's expected payoff from implementing this strategy is

$$V^{SM} = 1 + (\Delta_A + e)\, r - (0.5 + \Delta_A + e)\, U^{-1}(k/e)\,. \tag{13}$$

This contract benchmarks the manager's performance to the return of his designated market. The manager receives a positive reward if he secures the positive return of the market or avoids its negative return. Otherwise, he receives nothing. Consistent with the benchmarking idea, the same fund performance (0), could lead to two different compensations (0 or $\frac{k}{e}$) depending on whether the market return is positive or negative.

Another notable point is that the contract gives a zero payment for both $\binom{u}{d}$ and $\binom{d}{u}$, the outcomes in which the manager delivers maximum deviation from the primary market return. These terms represent penalties against the manager's tracking errors, which are often used in practice according to the BIS report (2003). These penalties discourage the manager from investing outside the primary market and serve the role of implementing a narrow investment mandate.

2.4 Two-tiered Strategy

Implementing the single-market strategy imposes an efficiency loss by restricting the manager from taking advantage of opportunities outside the primary market. This subsection studies a two-tiered strategy (see Table 1) which improves on this dimension: The manager exerts effort on acquiring a precise signal s_A^e about market A; if this signal is favorable, he invests in market A; if s_A^e is unfavorable but his free signal s_B indicates a good outside opportunity in market B, he invests in market B; otherwise, he invests in the risk free asset. Similar to the single-market strategy, the two-tiered strategy also induces the manager's effort in market A. However, in contrast to the single-market strategy, the two-tiered strategy instructs the manager to pursue outside opportunities if necessary.

2.4.1 The Least Costly Contract

We derive the least costly contract for implementing the two-tiered strategy in a way similar to the single-market strategy. By exerting effort and following the intended investment strategy, the manager's expected utility is

$$\begin{aligned} & \mathbb{E}\left[\overline{U}(c,\theta)\,|\text{exerting effort and following the two-tiered investment strategy}\right] \qquad (14) \\ = \; & 0.25\left[(1+2\Delta_A+2e)+(0.5-\Delta_A-e)(0.5+\Delta_B)\right]\pi_u^u+0.25(0.5+\Delta_A+e)(0.5+\Delta_B)\pi_d^u \\ & +0.25\left[(1-2\Delta_A-2e)+(0.5+\Delta_A+e)(0.5-\Delta_B)\right]\pi_d^d \\ & +0.25(0.5-\Delta_A-e)(0.5-\Delta_B)\pi_u^d+0.25(0.5+\Delta_A+e)\pi_d^0+0.25(0.5-\Delta_A-e)\pi_u^0-k. \end{aligned}$$

The manager can also adopt a deviation strategy by shirking and then following the two-tiered investment strategy based on his free signals s_A^0 and s_B:

$$\begin{aligned} & \mathbb{E}\left[\overline{U}(c,\theta)\,|\text{shirking and following the two-tiered investment strategy}\right] \qquad (15) \\ = \; & 0.25\left[(1+2\Delta_A)+(0.5-\Delta_A)(0.5+\Delta_B)\right]\pi_u^u+0.25(0.5+\Delta_A)(0.5+\Delta_B)\pi_d^u \\ & +0.25\left[(1-2\Delta_A)+(0.5+\Delta_A)(0.5-\Delta_B)\right]\pi_d^d \\ & +0.25(0.5-\Delta_A)(0.5-\Delta_B)\pi_u^d+0.25(0.5+\Delta_A)\pi_d^0+0.25(0.5-\Delta_A)\pi_u^0 \end{aligned}$$

Incentive compatibility requires that (14) dominates (15), which is equivalent to:

$$0.25e\left[(1.5-\Delta_B)\pi_u^u+(0.5+\Delta_B)\pi_d^u+\pi_d^0-\pi_u^0-(0.5-\Delta_B)\pi_u^d-(1.5+\Delta_B)\pi_d^d\right]\geq k. \qquad (16)$$

This is an important constraint in implementing the two-tiered strategy.

The principal also needs to ensure that after receiving a negative signal about market A and a positive signal about market B, the manager is willing to invest in market B instead of the risk-free asset. Investing in market B exposes the manager to the risk that the realized return might be negative, while investing in the risk-free asset allows the manager to lock in the sure return 0. The comparison of the two depends on the structure of the manager's incentive contract. Specifically, given $s_A^e = -1$ and $s_B = 1$, the manager's expected utility from investing in market B is

$$\begin{aligned}&(0.5 - \Delta_A - e)(0.5 + \Delta_B)\pi_u^u + (0.5 - \Delta_A - e)(0.5 - \Delta_B)\pi_u^d \\ &+ (0.5 + \Delta_A + e)(0.5 + \Delta_B)\pi_d^u + (0.5 + \Delta_A + e)(0.5 - \Delta_B)\pi_d^d,\end{aligned} \tag{17}$$

while his expected utility from investing in the risk-free asset is

$$(0.5 - \Delta_A - e)\pi_u^0 + (0.5 + \Delta_A + e)\pi_d^0. \tag{18}$$

Implementing the two-tiered strategy thus requires (17) dominate (18):

$$\begin{aligned}&(0.5 - \Delta_A - e)(0.5 + \Delta_B)\pi_u^u + (0.5 - \Delta_A - e)(0.5 - \Delta_B)\pi_u^d + (0.5 + \Delta_A + e)(0.5 + \Delta_B)\pi_d^u \\ &+ (0.5 + \Delta_A + e)(0.5 - \Delta_B)\pi_d^d - (0.5 - \Delta_A - e)\pi_u^0 - (0.5 + \Delta_A + e)\pi_d^0 \geq 0.\end{aligned} \tag{19}$$

This constraint also binds in the least costly contract.

The least costly contract minimizes the expected compensation cost $\mathbb{E}\left[U^{-1}(\pi_\omega)\right]$:

$$\begin{aligned}&0.25\left[(1 + 2\Delta_A + 2e) + (0.5 - \Delta_A - e)(0.5 + \Delta_B)\right]U^{-1}(\pi_u^u) + 0.25(0.5 - \Delta_A - e)U^{-1}\left(\pi_u^0\right) \\ &+0.25\left[(1 - 2\Delta_A - 2e) + (0.5 + \Delta_A + e)(0.5 - \Delta_B)\right]U^{-1}\left(\pi_d^d\right) + 0.25(0.5 + \Delta_A + e)U^{-1}\left(\pi_d^0\right) \\ &+0.25(0.5 - \Delta_A - e)(0.5 - \Delta_B)U^{-1}\left(\pi_u^d\right) + 0.25(0.5 + \Delta_A + e)(0.5 + \Delta_B)U^{-1}(\pi_d^u),\end{aligned} \tag{20}$$

subject to the incentive constraints in (16) and (19) and that all payments are non-negative. We denote the lagrange multipliers associated with the two incentive constraints as $\lambda_1 \geq 0$ and $\lambda_2 \geq 0$ respectively. The following proposition characterizes the least costly contract. We also verify other deviation strategies based on this incentive contract in Appendix A.2.

Proposition 2 *The least costly contract for implementing the two-tiered strategy gives zero payments for the following outcomes:*

$$\pi_u^0 = \pi_u^d = \pi_d^d = 0,$$

and positive payments for π_u^u, π_d^u, and π_d^0, which are given in Appendix A.2 and satisfy $\pi_u^u < \pi_d^u$ and $\pi_d^0 < \pi_d^u$. Under the sufficient conditions (35) and (36) in Appendix A.2, this contract also deters the use of other deviation strategies.

To implement the two-tiered strategy, the expected compensation cost is

$$
\begin{aligned}
K^{TT} \;=\;& 0.25 \left\{ \left[(1 + 2\Delta_A + 2e) + (0.5 - \Delta_A - e)(0.5 + \Delta_B) \right] U^{-1}(\pi_u^u) \right. \\
& \left. + (0.5 + \Delta_A + e)(0.5 + \Delta_B) U^{-1}(\pi_d^u) + (0.5 + \Delta_A + e) U^{-1}\left(\pi_d^0\right) \right\},
\end{aligned}
$$

and the principal's expected payoff is

$$1 + (e + \Delta_A + 0.5\Delta_B) r - K^{TT}.$$

Proposition 2 shows that to encourage the manager to pursue potential investment opportunities outside his primary market, the least costly incentive contract tolerates greater tracking errors than the one for implementing the single-market strategy (Proposition 1). This difference is reflected by the positive payment for the outcome $\binom{u}{d}$, in which the fund return beats the primary market return by two notches. Because of the large tracking error, this seemingly good performance is not rewarded by the contract derived in Proposition 1. Furthermore, the contract derived in Proposition 2 also provides a greater incentive slope, i.e., a larger payment for better performance as reflected by $\pi_d^u > \pi_u^u$ and $\pi_d^u > \pi_d^0$. In contrast, the contract derived in Proposition 1 provides the same payment for the two good outcomes: $\pi_u^u = \pi_d^0$.

In practice, hedge funds tend to be more tolerant of tracking errors and provide greater incentive slopes, whereas mutual funds tend to be more restrictive on tracking errors and give smaller incentive slopes. Thus, the contract derived in Proposition 2 is closer to the hedge fund contracts, while the contract derived in Proposition 1 is closer to the mutual fund contracts.

2.4.2 Higher Agency Cost due to Worse Benchmarking

Interestingly, the seemingly superior two-tiered strategy may be suboptimal because it exacerbates the agency cost to incentivize the manager to exert effort in his primary market. This negative impact originates from two channels. First, the additional investment flexibility makes "benchmarking" more difficult because it introduces luck from market B into the fund performance. This weakens the link between the fund performance and the manager's effort in market A, and leads to less efficient incentive provision. Second, implementing the two-tiered investment strategy requires an additional constraint (19) on the incentive contract, which further reduces its incentive provision efficiency. The intuition for the second channel is obvious. Thus, we focus on illustrating the first channel, which is also the key economic insight of our model.

The negative impact of investment flexibility on incentive provision manifests itself in the payment for the outcome $\omega = \binom{u}{u}$. In implementing the two-tiered strategy, the probability of this outcome is

$$p_\omega = 0.5\,(0.5 + \Delta_A + e) + 0.25\,(0.5 - \Delta_A - e)\,(0.5 + \Delta_B)\,. \tag{21}$$

The first term represents the situation that the primary market return is high (with probability 0.5) and the manager spots this opportunity (with probability $0.5 + \Delta_A + e$). The second term represents an additional possibility that the primary market return is high (with probability 0.5) but the manager fails to spot it (with probability $0.5 - \Delta_A - e$); instead, the return in market B is also high (with probability 0.5) and the manager spots this one (with probability $0.5 + \Delta_B$). The second term represents luck from market B. Such luck increases the probability for the principal to make the positive payment and thus adds to the compensation cost.

More interestingly, the luck also reduces the incentive leverage of π_u^u. If the manager shirks, the probability of this outcome becomes

$$0.5\,(0.5 + \Delta_A) + 0.25\,(0.5 - \Delta_A)\,(0.5 + \Delta_B)\,. \tag{22}$$

Thus, the difference between (21) and (22) gives the incentive leverage of π_u^u:

$$Dp_\omega = 0.5e - 0.25\,(0.5 + \Delta_B)\,e.$$

Comparing to (10) when implementing the single-market strategy, where $Dp_\omega = 0.5e$, the above incentive leverage is reduced by the possible luck from market B. Intuitively, the free luck from market B crowds out the need to exert effort to spot the good opportunity in market A (if there is one). This crowding out effect, which is at work only when implementing the two-tiered strategy, reduces the manager's gain from exerting his effort in market A and therefore his ex ante working incentives.

We call the ratio $\frac{p_\omega}{Dp_\omega}$ the cost to incentive ratio of the payment, which is first derived in Holmstrom (1979).[18] The numerator p_ω captures a *cost* effect, i.e., the larger the probability of the outcome ω, the higher the expected cost of each dollar promised to this outcome. The denominator Dp_ω captures an *incentive* effect: the larger the incentive leverage Dp_ω, the

[18] $\frac{Dp_\omega}{p_\omega}$ corresponds to $\frac{f_a}{f}$ in Holmstrom (1979), where f is the probability density function of the performance, and f_a is the marginal impact of action a on the density function. Holmstrom points out that $\frac{f_a}{f}$ is the derivative of log likelihood, and interprets this measure as how strongly one is inclined to infer from the performance that the agent did not take the assumed action.

greater the manager's incentive to exert effort. In implementing the two-tiered strategy, we have

$$\left(\frac{p}{Dp}\right)_{\omega} = \frac{0.5\,(0.5+\Delta_A+e)+0.25\,(0.5-\Delta_A-e)\,(0.5+\Delta_B)}{0.5e-0.25\,(0.5+\Delta_B)\,e}$$

$$= \frac{0.5\,(0.5+\Delta_A+e)+\overbrace{0.25\,(0.5-\Delta_A-e)\,(0.5+\Delta_B)}^{\text{increased } p_\omega \text{ due to luck from market } B}}{0.5e-\underbrace{0.25\,(0.5+\Delta_B)\,e}_{\text{reduced incentive}}}.$$

We have decomposed each term in the fraction relative to $\frac{0.5+\Delta_A+e}{e}$, the corresponding cost to incentive ratio in implementing the single market strategy. It is clear that the investment flexibility unambiguously increases the cost to incentive ratio by raising the expected payment and lowering the incentive leverage of the payment.

Overall, implementing the two-tiered strategy requires a higher expected compensation cost, which we formally prove in the following proposition.

Proposition 3 *The expected compensation cost of implementing the two-tiered strategy is higher than that of the single-market strategy, i.e.,* $K^{TT} > K^{SM}$*. Furthermore, the difference monotonically increases with* k*.*

This proposition shows that in implementing the two-tiered strategy, the additional investment benefit $0.5r\Delta_B$ from encouraging the manager to pursue the opportunity outside the primary market comes with an increased agency cost of $K^{TT} - K^{SM}$. As the increased agency cost monotonically increases with k, the principal will prefer the narrowly mandated single-market strategy if k is higher than a certain threshold k^*.

We can intuitively relate the model parameter k to the manager's ability and the information opacity of the primary market. As the effort cost of the more talented managers is lower, the additional agency cost from encouraging them to pursue opportunities outside their primary markets is also smaller. As a result, we have the following implication:

Implication 1: Fund managers with lower ability are more likely to be confined in trading a specific market sector or asset class; on the other hand, managers with higher ability tend to face less stringent investment mandates.

This implication is consistent with a casual observation that hedge fund managers tend to be more talented than mutual fund managers,[19] and they also face less stringent investment mandates.

[19] See Kostovetsky (2009) for evidence of a drop in mutual fund returns as a result of a flight of top-performing young managers from mutual funds to hedge funds.

Furthermore, the effort cost is likely to be higher for managers whose primary markets are more informationally opaque. This in turn leads to another testable implication:

Implication 2: Fund managers whose primary markets are more informationally opaque face more stringent investment mandates.

2.5 Model Robustness

Our model makes several simplifying assumptions to make the analysis tractable. These assumptions include the restriction preventing the manager from taking multiple positions in markets A and B at the same time, the short-sale constraints in both markets A and B, and the restriction on the manager's position to be either 1 or 0 unit in each market. These assumptions are not essential to the key economic insight of our model.

Appendix B presents an alternative model setting, which relaxes the restrictions on multiple positions and short sales. Specifically, the manager can take either a long or short position of one unit in the primary market A, and at the same time he can also independently take a long or short position of one unit in the secondary market B. We show that the key result derived from our main model prevails—when the manager's cost of effort in the primary market is sufficiently high or when the precision of the manager's free signal about market B is sufficiently low, motivating the manager to pursue the single-market strategy that invests exclusively in the primary market is optimal even though the free signal about the secondary market is nevertheless valuable. The driver of this result is the same as in Section 2.4.2: Because the principal cannot directly observe the manager's investment positions and the fund performance aggregates the manager's returns from both markets, investment flexibility across both markets impedes the principal's inference problem of the manager's effort. As a result, incentive provision becomes inefficient and more costly.

The restriction on the manager's position of 1 or 0 unit serves to prevent the portfolio return from fully revealing the manager's investment position. With both markets A and B having binomial returns, allowing the manager to choose investment position in a continuous range such as $[0, 1]$ would allow the principal to perfectly infer the manager's position based on his portfolio return and the primary market return—for example, if the principal can design a contract to induce the manager to either invest 100% in market A or 99% in market B. However, the continuously distributed asset returns in reality render such a revelation mechanism unrealistic. Thus, we do not believe that this assumption is essential to our key economic insight.

3 An Extended Model with Negatively Skewed Risk

When incentivized to pursue investment opportunities outside his primary market, the manager may also seek unwarranted negatively skewed risk even if his signals do not indicate any good opportunity. In light of the recent financial crisis, many observers (e.g., Rajan (2010) and Acharya, Cooley, and Richardson (2010)) had pointed out that excessive risk taking (by AIG, Lehman Brothers, and other financial firms), and in many cases active seeking of negatively skewed risk, was a key contributing factor of the crisis. As highlighted by Rajan (2010), such tail risk presents a great challenge to the ongoing reform of the financial industry's risk management system and incentive structure: "*We have to find ways to reduce the incentive to take tail risk even while rewarding bankers for performance so that they continue to offer innovative products that meet customer needs and lend to the risky but potentially very successful start-up.*"

3.1 Negative Skewness and Analysis

We suppose that one of the markets outside the manager's primary market, denoted by market C, has a zero expected return and a negative skewness, in addition to market B specified earlier.[20] Again, only the manager knows the identity of this market. Specifically, market C offers the following return:

$$\widetilde{r}_C = \begin{cases} r & \text{with probability } \eta_C \in (0.5, 1) \\ -\frac{\eta_C}{1-\eta_C} r & \text{with probability } 1 - \eta_C \in (0, 0.5) \end{cases}.$$

A higher value of η_C leads to a more negatively skewed return, i.e., this market gives a positive return r with a high probability η_C but a large negative return $-\frac{\eta_C}{1-\eta_C} r$ with a small probability $1 - \eta_C$. The manager does not observe any signal about this market—market C represents a pure gamble.[21]

[20] While in practice a fund manager can seek risk in either his primary market or any outside market, this concern is perhaps more severe for outside markets. This is because his primary market is usually tightly defined and thus offers limited flexibility to seek risk. On the other hand, once incentivized to invest outside, the manager's flexibility to seek any type of payoff or risk in the complex financial universe is greatly increased. Thus, our analysis focuses on the manager's risk seeking incentive that accompanies his incentive to pursue outside investment opportunities.

[21] To highlight the damage caused by market C to the manager's incentive, we intentionally make its expected return zero. This expected return per se is not a concern to the risk-neutral principal. Instead, as we will highlight, the presence of this market not only erodes the manager's effort incentive but also makes it more difficult to implement an efficient investment strategy. It should be clear that making the expected return of market C negative by further reducing its negative return will only strengthen our result.

The presence of such a market further complicates the delegation problem between the principal and the manager. Suppose that the manager is compensated by the incentive contract derived in Proposition 2 which aims to induce effort and implement the two-tiered investment strategy in markets A and B. If the manager invests in market C, this can be detected only after the realization of loss $-\frac{\eta_C}{1-\eta_C} r$ that is more severe than those from other regular investments. When this occurs, limited liability implies that the principal can only penalize the manager by paying him zero. On the other hand, if the outcome is positive, the principal cannot identify the source of the good performance and has to compensate the manager according to the contract.

The following scenario demonstrates this risk-seeking behavior clearly. Consider the investment problem faced by the manager when he observes a negative signal in market A and a positive signal in market B (i.e., $s_A^e = -1$ and $s_B = 1$). His expected utility from investing in market B is

$$(0.5 - \Delta_A - e) \left[(0.5 + \Delta_B) \pi_u^u + (0.5 - \Delta_B) \pi_u^d \right] + (0.5 + \Delta_A + e) \left[(0.5 + \Delta_B) \pi_d^u + (0.5 - \Delta_B) \pi_d^d \right],$$

which, under the contract in Proposition 2, is equal to $(0.5 + \Delta_B) [(0.5 - \Delta_A - e) \pi_u^u + (0.5 + \Delta_A + e) \pi_d^u]$. His expected utility from investing in market C is $\eta_C [(0.5 - \Delta_A - e) \pi_u^u + (0.5 + \Delta_A + e) \pi_d^u]$ as he will get compensated after market C gives a positive return and zero otherwise. Thus, the manager will choose to invest in market C if and only if

$$\eta_C > 0.5 + \Delta_B.$$

That is to say, the manager will ignore a good opportunity in market B and instead seek the unwarranted risk in market C if the negative skewness η_C is sufficiently large. This exactly captures the concern that compensation for positive performance can also motivate the manager to seek negatively skewed risk.[22]

This illustration suggests that additional constraints are necessary to prevent the manager from seeking the negatively skewed risk in market C. It turns out that if the manager deviates from the intended investment strategy, he prefers a double-deviation strategy to first shirk and then seek risk in market C regardless of his signals. Deterring such a double-deviation provides the most-binding constraint on the incentive contract.[23] If the manager chooses to

[22] The incentive to seek negatively skewed risk will arise as long as the manager faces a sufficiently large reward for good performance and is protected by limited liability. By endogenizing the manager's compensation contract through the agency problem, our model allows us to analyze the interaction between effort-motivating incentive and risk-seeking incentive in determining the optimal incentive structure for fund managers.

[23] This situation is similar to the optimality of double-deviation in the dynamic moral hazard problem

shirk in the primary market and then to always invest in market C, his expected utility is (the manager gets zero if market C has negative outcome)

$$\eta_C 0.5 \left(\pi_u^u + \pi_d^u\right).$$

His expected utility from exerting effort and following the two-tiered investment strategy is given in (14). Thus, the additional constraint is

$$\begin{aligned}
&0.25 \left[(1 + 2\Delta_A + 2e) + (0.5 - \Delta_A - e)(0.5 + \Delta_B)\right] \pi_u^u + 0.25 (0.5 + \Delta_A + e)(0.5 + \Delta_B) \pi_d^u \\
&+0.25 \left[(1 - 2\Delta_A - 2e) + (0.5 + \Delta_A + e)(0.5 - \Delta_B)\right] \pi_d^d + 0.25 (0.5 - \Delta_A - e)(0.5 - \Delta_B) \pi_u^d \\
&+0.25 (0.5 + \Delta_A + e) \pi_d^0 + 0.25 (0.5 - \Delta_A - e) \pi_u^0 - k \geq 0.5\eta_C \left(\pi_u^u + \pi_d^u\right). \qquad (23)
\end{aligned}$$

The rewards for positive performance stimulate the risk-seeking behavior because the right-hand side of this inequality increases with π_u^u and π_d^u. If these payments are high, the contract has to raise payments for other outcomes (possibly for bad performance), to increase the opportunity cost of seeking the negatively skewed risk. As a result, adding this constraint can further increase the agency cost of implementing the two-tiered investment strategy.

Recall that Proposition 2 shows that the least costly contract involves only three non-zero payments, in the absence of the negatively skewed risk. With the negatively skewed risk in market C, we need to minimize the expected compensation cost in (20) subject to constraints in (16), (19) and (23). The next proposition shows that when η_C is sufficiently large, the constraint in (23) is binding. As a result, the previously zero payments $\left\{\pi_d^d, \pi_u^d, \pi_u^0\right\}$ can now turn positive, and π_d^d turns positive before the other two.

Proposition 4 *When η_C is sufficiently large, the constraint in (23) is binding. Furthermore, π_d^d turns positive before π_u^d and π_u^0 under the sufficient condition that*

$$0.5 + \Delta_B < 2\Delta_A + 2e.$$

A positive payment π_d^d arises because it increases the opportunity cost for the manager to seek the unwarranted negatively skewed risk, i.e., the left-hand side of (23). Although we only prove that π_d^d turns positive before π_u^d and π_u^0 under the given sufficient condition, numerically we have verified that π_u^d and π_u^0 always remain zero in a large set of parameter values outside the sufficient condition.[24]

with private (hidden) saving, where the agent usually finds it optimal to shirk and save concurrently, e.g., He (2012). As investment positions are not observable in our model, investing in market C plays the same

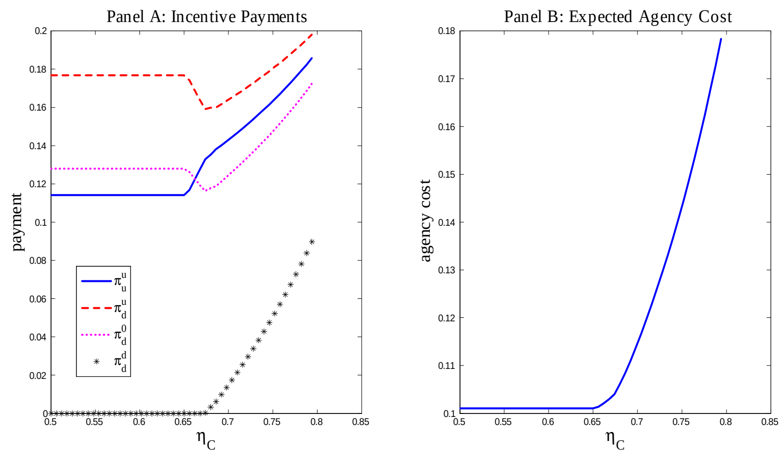

Figure 1: Effects of negatively skewed risk on the least costly incentive contract for implementing the two-tiered strategy. This figure uses the baseline parameters given in (24). Panel A plots the four payments π_u^u, π_d^u, π_d^0, and π_d^d against η_C, while Panel B plots the expected compensation cost.

To further illustrate the effects of negatively skewed risk on the least costly incentive contract for implementing the two-tiered strategy, we adopt the following baseline parameters:

$$r = 0.25,\ \Delta_A = 0.25,\ \Delta_B = 0.2,\ k = 0.02,\ e = 0.2,\ \alpha = 0.6. \tag{24}$$

Figure 1 plots four payments π_u^u, π_d^u, π_d^0, and π_d^d as η_C increases from 0.5 to 0.8. The risk-seeking constraint in (23) starts to bind when η_C passes 0.65, a level below $0.5 + \Delta_B = 0.7$. Consistent with our earlier discussion, this suggests that the double-deviation of shirking and risk-seeking is more desirable to the manager than the single deviation of risk-seeking only, and thus the constraint in (23) binds earlier than $\eta_C > 0.5 + \Delta_B$.

When η_C is between 0.65 and 0.67, the least costly contract offsets the risk-seeking incentive by increasing π_u^u, reducing π_d^u and π_d^0, and keeping π_d^d at zero. As we have discussed, π_u^u is useful for deterring risk seeking because its coefficient on the left-hand side of (23) is greater than that on the right-hand side. As a result, the expected compensation cost increases with η_C.

role as private saving in that context.

[24] What makes π_d^d different from π_u^d and π_u^0? Although their cost to incentive □ratios in motivating the manager's effort are all negative, the cost to incentive ratio of □$^{d}_{d}$) is □ $[(1$ □ $2\Delta_A$ □ $2e) + (0.5 + \Delta_A + e)(0.5$ □ $\Delta_B)] / (1.5 + \Delta_B) / e$, which is lower than (so the absolute value is higher than) that of □$^{d}_{u}$) and □$^{0}_{u}$) with $\left(\frac{p}{Dp}\right)_u^d = \left(\frac{p}{Dp}\right)_u^0 =$ □ $(0.5$ □ Δ_A □ $e) / e$. Section 2.4.2 then tells us that it is more difficult for the principal to use the outcome □$^{d}_{d}$) to distinguish (bad) performance from (bad) luck. As a result, if the principal has to pay the manager that comes with a negative impact on effort incentives, a payment for □$^{d}_{d}$) causes the least damage.

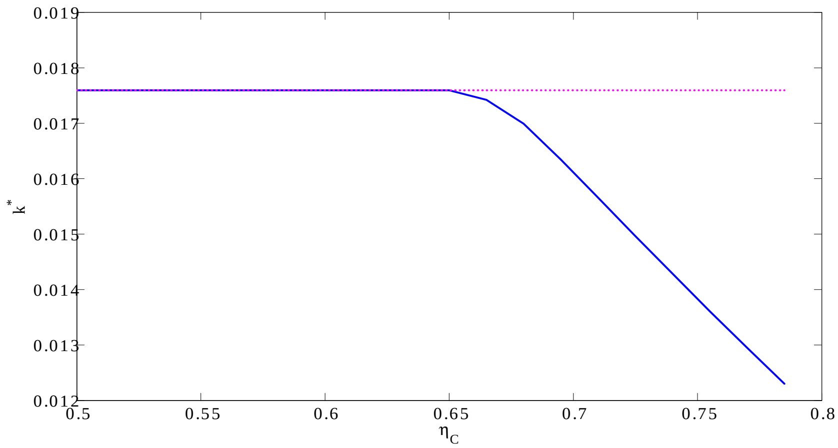

Figure 2: The increasing use of narrow mandates in the presence of negatively skewed risk. This solid line plots k^*, the upper threshold on the manager's effort cost parameter for implementing the two-tiered investment strategy, against η_C based on the baseline parameters given in (24). The dashed line gives the threshold level when the negatively skewed risk is absent from the model.

When η_C rises above 0.67, simply increasing π_u^u is not enough. Instead, the contract gives a positive payment π_d^d even though it has a negative effect on inducing the manager's effort in the primary market. To counter the negative incentive effect brought on by π_d^d, the contract has to simultaneously increase the other three payments (π_u^u, π_d^u, and π_d^0) which have positive incentive effects. Because of the intricate interaction between the manager's incentive-provision constraint and risk-seeking constraint, the expected compensation cost increases dramatically with η_C once it passes above 0.67.

Furthermore, Figure 1 shows that the incentive slope π_d^u □ π_u^u decreases with η_C. This is because π_d^u is particularly strong in motivating the risk-seeking behavior—when η_C is large, the coefficient of π_d^u on the right-hand side of (23) exceeds that on the left-hand side. As a result, the contract has to reduce π_d^u to mitigate such an incentive.

The increased agency cost makes the single-market strategy more desirable. Figure 2 plots the upper threshold k^* of the manager's effort cost for the optimality of implementing the two-tiered strategy. When η_C is below 0.65, k^* is insensitive to η_C. As η_C rises above 0.65, k^* decreases with η_C. This plot suggests that in the presence of the negatively skewed risk, only managers with sufficiently high talents (and thus low effort cost) are encouraged to pursue investment opportunities outside their designated markets. The next proposition formally proves this result.

Proposition 5 *In the presence of the negatively skewed risk in market C, the upper threshold*

k^* on the manager's effort cost for the optimality of implementing the two-tiered strategy decreases with the skewness parameter η_C.

3.2 Implications

Taken together, our analysis demonstrates that the presence of negatively skewed risk increases the agency cost of encouraging the manager to pursue opportunities outside the primary market. As a result, narrow investment mandates become even more desirable. It is especially useful to interpret this result in light of the increasingly complex financial markets. The rapid development of financial markets in recent years has greatly expanded the space of financial securities and thus made it much easier to access negatively skewed risk, either by buying a structured finance product with the intended risk profile or by selling an out-of-money option like security. Together with this change in the investment environment, our model explains the recent trend of the growing popularity of stringent investment mandates and narrow tracking errors highlighted by the BIS report (2003).

Our model also shows that for those managers with exceptional talents, the optimal incentive contract not only encourages them to pursue flexible investment strategies but also rewards them generously. Interestingly, the reward covers not just their good performances but also their well-intentioned failures. The reward for failures might appear counter-intuitive because of its seemingly negative incentive effect. But it helps deter risk seeking because the managers stand to lose such a reward if they choose to seek outside risk. In other words, since managers get paid generously for pursuing the intended strategies, they will find seeking outside risk too costly as it jeopardizes the generous payments guaranteed to them.

Philippon and Reshef (2008) find that wages for financial jobs were excessively high around 1930 and from the mid 1990s to 2006. They attribute the high wages to financial deregulation during these periods, which made financial jobs more skill intensive and complex and thus attracted better talents to the financial industry. In light of our analysis, financial deregulation not only makes financial jobs more demanding, but also creates more room for traders and fund managers to take on creative negatively skewed risk. As a result, higher wages are necessary not only because the financial workers' reservation wages were higher, but also because the damages they could do to the firms were also higher.

4 Discussions

The wide usage of narrow investment mandates in the asset management industry have important implications for asset market dynamics. In this section, we discuss such implications on capital immobility and market segmentation.

4.1 Capital Immobility

The stringent investment mandates imposed on fund managers can lead to "capital immobility," i.e., capital often fails to flow to distressed markets that offer profitable opportunities. Duffie (2010) highlights this phenomenon as an important factor in understanding market liquidity. For example, many pundits observe that capital immobility was a key factor leading to the 1998 financial market crisis - margin calls forced the hedge fund Long Term Capital Management to liquidate its large leveraged positions in fixed income securities while not enough capital came to absorb its liquidation. Froot and O'Connell (1999) show that the supply of capital in the catastrophe insurance market is inelastic because there are times during which the price of catastrophe insurance seems to be high and the capital of catastrophe insurers is low. Other examples include the depressed convertible bond market after convertible hedge funds faced large redemption of capital from investors in 2005 (e.g., Mitchell, Pedersen, and Pulvino, 2008), the temporary price discount for stocks after fire sales by mutual funds (e.g., Coval and Stafford, 2007), and the distressed market for newly down-graded junk bonds (e.g., Da and Gao, 2008).

Our model provides a new hypothesis for capital immobility during liquidity crises based on agency frictions at the *originating* end of capital flow. The economy could well have adequate capital. However, once investors distribute their capital into different market segments through institutionally managed funds, agency considerations can motivate stringent investment mandates on the fund managers, which in turn confine the capital in its initial market segments. Even if one segment runs out of capital later and ends up in a liquidity crisis, fund managers in other market segments may be unwilling to move in because of the potential tracking errors. Instead, the strategic decisions of moving capital across different segments are largely left to the less informed investors themselves. As a result, the capital flow is likely to be delayed. Only as the crisis deteriorates will the distressed segment gradually attract capital from other segments, starting from funds that face broader investment mandates and greater tolerance for tracking errors. Eventually, investors will also recognize profit opportunities created by the crisis and move capital from other segments to the distressed segment.

Our agency based hypothesis of capital immobility complements the growing literature that studies the impact of financial intermediaries' capital inside the crisis market under the premise that outside capital would not flow in (e.g., Kyle and Xiong (2001), Gromb and Vayanos (2002), Brunnermeier and Pedersen (2009), He and Krishnamurthy (2012a,b), and Bolton, Santos, and Scheinkman (2011)). These studies typically motivate this premise based on various information barrier arguments about the distressed market at the *receiving* end of capital flow, e.g., outside investors hesitate to invest in the crisis market because they cannot distinguish whether the price drop is driven by liquidity reasons or worsened fundamentals. Our hypothesis is also different from those based on search frictions (e.g., Duffie (2010)), who suggest that the speed of capital flow depends on the rate of random matching between buyers and sellers.

4.2 Market Segmentation

There is growing evidence of de facto segmentation of various asset markets from the broad financial markets, even in the absence of explicit regulatory and physical constraints on investment to these markets. For example, Bekaert, Harvey, Lundblad, and Siegel (2008) show that many emerging markets are still segmented from the global financial markets even though the regulatory constraints on foreign investment had been largely lifted over the past few decades. In particular, they find that after controlling for financial leverage and earnings volatility, emerging markets display a significantly higher industrial earnings yield (the inverse of price to earnings ratio) than that of developed countries. A common argument is that information barriers may prevent investors from fully integrating assets of emerging markets into their portfolios, e.g., Merton (1987). However, investors can hire professional managers to overcome the information barriers. Then, it remains puzzling that the rapid growth of funds specializing in emerging markets in the recent years has not eliminated the segmentation of these markets.

Several other markets also exhibit similar de facto segmentation. In the corporate bond market, Collin-Dufresne, Goldstein, and Martin (2001) find that proxies for both changes in the probability of future default based on standard fundamental-driven credit risk models and for changes in the recovery rate can explain only a small fraction of the observed credit spread changes. Instead, a market-specific latent factor can explain a large fraction of the residuals. In the mortgage-backed securities market, Gabaix, Krishnamurthy, and Vigneron (2007) find that idiosyncratic prepayment risk carries a risk premium. In the S&P 500 index option market, Garleanu, Pedersen, and Poteshman (2009) find that demand pressure in one option contract increases its price as well as other correlated contracts. The de facto segmentation of these markets is even more puzzling as they are mostly traded by financial institutions and professional traders.

The narrow investment mandates derived in our model provide an explanation of the de facto segmentation of the aforementioned markets. When (uninformed) investors delegate their capital to a professional manager to invest in one of these markets, information barriers in these markets make it necessary to impose a stringent investment mandate on the manager in order to reduce agency cost in the delegation process. In other words, the manager has to invest primarily in this particular market, say Russia, and his compensation is closely tied to his fund performance. Thus, despite that the manager might work for well-diversified investors, his own pricing kernel is exposed to the idiosyncratic risk of the market. The market will exhibit de facto segmentation if the manager is the marginal investor. To sum up, our model suggests that agency frictions can lead to market segmentation despite that investors can hire professional managers to overcome information barriers in informationally opaque markets.

5 Conclusion

We analyze a realistic delegated asset management problem in which a principal hires a fund manager to invest his money in a multi-market environment. This implies that the principal needs to motivate not only the manager's effort in acquiring information, but also an investment strategy across the markets. Our model highlights a tradeoff between encouraging the manager to pursue the efficient investment strategy and the agency cost of incentivizing him. This tradeoff becomes especially severe when the manager can access negatively skewed risk outside his primary market. Building on this tradeoff, our model explains the increasingly stringent investment mandates faced by fund managers. Our analysis sheds light on capital immobility and market segmentation that are widely observed in financial markets and highlights important effects of negatively skewed risk on institutional incentive structures.

Appendix

A Proofs of Propositions

A.1 Proof of Proposition 1

We need to verify that the manager has no incentive to deviate and invest in market B. First, consider a deviation strategy that he exerts effort on market A and then follows the two-tiered investment strategy discussed in Section 2.4 (i.e., invest in market B when $s_A^e = 0$ and $s_B^0 = 1$). The relevant situation is when he observes a negative signal in market A and a positive signal in market B. Then, his expected utility from investing in market B is

$$\begin{aligned}&0.25\,(0.5 - \Delta_A - e)\,(0.5 + \Delta_B)\,\pi_u^u + 0.25\,(0.5 - \Delta_A - e)\,(0.5 - \Delta_B)\,\pi_u^d \\ &+0.25\,(0.5 + \Delta_A + e)\,(0.5 + \Delta_B)\,\pi_d^u + 0.25\,(0.5 + \Delta_A + e)\,(0.5 - \Delta_B)\,\pi_d^d\end{aligned}$$

which, under the contract specified in Proposition 1, is equal to $0.25\,(0.5 - \Delta_A - e)\,(0.5 + \Delta_B)\,\pi_u^u$; if his expected return from investing in the risk-free asset is

$$(0.5 + \Delta_A + e)\,\pi_d^0 + (0.5 - \Delta_A - e)\,\pi_u^0$$

which is equal to $(0.5 + \Delta_A + e)\,\pi_d^0$ under the contract specified in Proposition 1. As $\pi_u^u = \pi_d^0$, the manager prefers to invest in the risk-free asset.

Next, we consider the deviation strategy that he exerts no effort and follows a two-tiered investment strategy. Then, his expected utility is

$$\begin{aligned}&0.25\,[(1 + 2\Delta_A) + (0.5 - \Delta_A)\,(0.5 + \Delta_B)]\,\pi_u^u + 0.25\,(0.5 + \Delta_A)\,(0.5 + \Delta_B)\,\pi_d^u \\ &+0.25\,[(1 - 2\Delta_A) + (0.5 + \Delta_A)\,(0.5 - \Delta_B)]\,\pi_d^d + 0.25\,(0.5 - \Delta_A)\,(0.5 - \Delta_B)\,\pi_u^d \\ &+0.25\,(0.5 + \Delta_A)\,\pi_d^0 + 0.25\,(0.5 - \Delta_A)\,\pi_u^0,\end{aligned}$$

which is modified from equation (14) by removing the manager's effort. Under the contract given in Proposition 1, the manager's expected utility is equal to

$$\begin{aligned}&\quad 0.25\,[(1 + 2\Delta_A) + (0.5 - \Delta_A)\,(0.5 + \Delta_B)]\,\pi_u^u + 0.25\,(0.5 + \Delta_A)\,\pi_d^0 \\ &= 0.25\,[(0.5 - \Delta_A)\,(0.5 + \Delta_B) + 1.5 + 3\Delta_A]\,\frac{k}{e} \\ &< 0.25\,[(0.5 - \Delta_A) + 1.5 + 3\Delta_A]\,\frac{k}{e} = 0.5\,(1 + \Delta_A)\,\frac{k}{e}.\end{aligned}$$

By substituting the equilibrium contract into equation 8, the manager's expected utility from exerting effort and following the single-market strategy is $0.5\,(1 + 2\Delta_A)\,\frac{k}{e}$, which is strictly higher than that from the deviation strategy.

A.2 Proof of Proposition 2

We need to minimize the expected compensation cost in (20) subject to the two incentive constraints in (16) and (19). For the six incentive payments π_d^0, π_u^d, π_d^d, π_u^u, π_d^u, and π_u^0, the first-order conditions subject to the two constraints are

$$\frac{(1+2\Delta_A+2e)+(0.5-\Delta_A-e)(0.5+\Delta_B)}{U'\left[U^{-1}(\pi_u^u)\right]} \geq \lambda_1 e\,(1.5-\Delta_B)+\lambda_2\,(0.5-\Delta_A-e)(0.5+\Delta_B) \tag{25}$$

with equality if $\pi_u^u > 0$;

$$\frac{(0.5+\Delta_A+e)(0.5+\Delta_B)}{U'\left[U^{-1}(\pi_d^u)\right]} \geq \lambda_1 e\,(0.5+\Delta_B)+\lambda_2\,(0.5+\Delta_A+e)(0.5+\Delta_B) \tag{26}$$

with equality if $\pi_d^u > 0$;

$$\frac{(1-2\Delta_A-2e)+(0.5+\Delta_A+e)(0.5-\Delta_B)}{U'\left[U^{-1}\left(\pi_d^d\right)\right]} \geq -\lambda_1 e\,(1.5+\Delta_B)+\lambda_2\,(0.5+\Delta_A+e)(0.5-\Delta_B) \tag{27}$$

with equality if $\pi_d^d > 0$;

$$\frac{(0.5-\Delta_A-e)(0.5-\Delta_B)}{U'\left[U^{-1}(\pi_u^d)\right]} \geq -\lambda_1 e\,(0.5-\Delta_B)+\lambda_2\,(0.5-\Delta_A-e)(0.5-\Delta_B) \tag{28}$$

with equality if $\pi_u^d > 0$;

$$\frac{(0.5+\Delta_A+e)}{U'\left[U^{-1}(\pi_d^0)\right]} \geq \lambda_1 e-\lambda_2\,(0.5+\Delta_A+e) \tag{29}$$

with equality if $\pi_d^0 > 0$;

$$\frac{(0.5-\Delta_A-e)}{U'\left[U^{-1}(\pi_u^0)\right]} \geq -\lambda_1 e-\lambda_2\,(0.5-\Delta_A-e)\,, \tag{30}$$

with equality if $\pi_u^0 > 0$.

The following lemma verifies that both λ_1 and λ_2 are positive.

Lemma 1 $\lambda_1 > 0$ *and* $\lambda_2 > 0$.

Proof. *First, the incentive constraint in (16) must be binding. This is because if this constraint is slack, the solution to minimize the compensation cost would be to set all payments to be zero. This solution, however, violates the constraint in (16). Thus,* $\lambda_1 > 0$. *Now suppose that* $\lambda_1 > 0$ *but* $\lambda_2 = 0$, *i.e., the constraint in (19) is slack. By minimizing the compensation cost subject to (16) we have*

$$\pi_u^0 = \pi_u^d = \pi_d^d = 0, \text{ and } \pi_d^u = \pi_d^0 > \pi_u^u > 0.$$

To see this, setting $\lambda_2 = 0$, then

$$\begin{aligned} U'\left[U^{-1}\left(\pi_d^u\right)\right] &= U'\left[U^{-1}\left(\pi_d^0\right)\right] = \frac{0.5+\Delta_A+e}{\lambda_1 e} \\ &< \frac{(1+2\Delta_A+2e)+(0.5-\Delta_A-e)(0.5+\Delta_B)}{\lambda_1 e\,(1.5-\Delta_B)} = U'\left[U^{-1}\left(\pi_u^u\right)\right] \end{aligned}$$

Since $U'\left[U^{-1}(\pi)\right]$ is strictly decreasing in π, we have our claim. Now given this, it is direct to verify that this solution violates the constraint in (19). Therefore, both constraints must be binding, i.e., $\lambda_1 > 0$ and $\lambda_2 > 0$. ■

As $\lambda_1 > 0$ and $\lambda_2 > 0$, the right-hand side of equation (30) is negative. Thus, $\pi_u^0 = 0$. Intuitively, this is because π_u^0 has a negative incentive differential $Dp_\omega < 0$ in both of the incentive constraints (16) and (19).

The following lemma further determines π_u^d and π_d^d to be zero.

Lemma 2 *If $\pi_d^0 > 0$, then $\pi_u^d = \pi_d^d = 0$.*
Proof. *Based on (29), $\pi_d^0 > 0$ requires that $\lambda_1 e > \lambda_2(0.5+\Delta_A+e)$. Therefore, $\pi_u^d = 0$ and $\pi_d^d = 0$ because the right-hand side of (27) and (28) are negative, while the left-hand side is always positive.* ■

As a result, there are only three positive payments: π_d^u, π_d^0, and π_u^u in the least costly contract. These three payments, together with λ_1 and λ_2, satisfy the binding incentive constraints in (16) and (19):

$$(1.5-\Delta_B)\,e\pi_u^u + (0.5+\Delta_B)\,e\pi_d^u + e\pi_d^0 = 4k \tag{31}$$

$$(0.5-\Delta_A-e)(0.5+\Delta_B)\,\pi_u^u + (0.5+\Delta_A+e)(0.5+\Delta_B)\,\pi_d^u - (0.5+\Delta_A+e)\,\pi_d^0 = 0 \tag{32}$$

and the first-order-conditions in (25), (26), (29).

The following lemma provides the ranks of the three positive payments.

Lemma 3 *$\pi_d^u > \pi_d^0$ and $\pi_d^u > \pi_u^u$.*
Proof. *Since $\lambda_2 > 0$, equations (26) and (29) directly imply that $\pi_d^u > \pi_d^0$. To show $\pi_d^u > \pi_u^u$, note that*

$$\begin{aligned} \frac{1}{U'\left[U^{-1}\left(\pi_u^u\right)\right]} &= \frac{e(1.5-\Delta_B)\lambda_1 + (0.5-\Delta_A-e)(0.5+\Delta_B)\lambda_2}{(1+2\Delta_A+2e)+(0.5-\Delta_A-e)(0.5+\Delta_B)} \\ &< \frac{e(1.5-\Delta_B)\lambda_1}{(1+2\Delta_A+2e)+(0.5-\Delta_A-e)(0.5+\Delta_B)} + \lambda_2. \end{aligned}$$

Because $\frac{1}{U'\left[U^{-1}\left(\pi_d^u\right)\right]} = \frac{\lambda_1 e}{0.5+\Delta_A+e} + \lambda_2$, it suffices to show that

$$\frac{1.5-\Delta_B}{(1+2\Delta_A+2e)+(0.5-\Delta_A-e)(0.5+\Delta_B)} < \frac{1}{0.5+\Delta_A+e}$$

which holds because $1.5-\Delta_B < 2$. ■

We need to verify that the manager will not pursue any deviation strategy. Two of these strategies have been considered in the main text. Consider the following deviation strategy: the manager shirks; he invests in market A if $s_A^0 = 1$, otherwise he gambles in market B regardless of s_B. To prevent the use of this strategy, we require that his expected utility from using it

$$0.25\,(1.5+\Delta_A)\,\pi_u^u + 0.25\,(0.5+\Delta_A)\,\pi_d^u + 0.25\,[1.5-\Delta_A]\,\pi_d^d + 0.25\,(0.5-\Delta_A)\,\pi_u^d \tag{33}$$

to be dominated by his expected utility given in (14). Another deviation strategy is shirking, investing in market B if $s_B = 1$, and otherwise gambling in market A. To prevent the use of this strategy we also require that the manager's expected utility from this strategy

$$0.25\,[1.5+\Delta_B]\,\pi_u^u + 0.25\,(0.5+\Delta_B)\,\pi_d^u + 0.25\,[1.5-\Delta_B]\,\pi_d^d + 0.25\,(0.5-\Delta_B)\,\pi_u^d \tag{34}$$

to be dominated by that in (14). Note that $\pi_d^u > \pi_d^d$ and $\pi_u^d = 0$ in the derived optimal contract. As $\Delta_A \geq \Delta_B$, the manager's expected utility from using the first deviation strategy in (33) dominates that from using the second one in (34). Therefore to verify that (33) is dominated by (14) it suffices to show that

$$\begin{aligned} & [1+2\Delta_A+(0.5-\Delta_A)(0.5+\Delta_B)]\,\pi_u^u + (0.5+\Delta_A)(0.5+\Delta_B)\,\pi_d^u + (0.5+\Delta_A)\,\pi_d^0 \\ \geq\; & (1.5+\Delta_A)\,\pi_u^u + (0.5+\Delta_A)\,\pi_d^u, \end{aligned}$$

which is equivalent to

$$[(0.5-\Delta_A)\,\pi_u^u + (0.5+\Delta_A)\,\pi_d^u]\,(0.5-\Delta_B) \leq (0.5+\Delta_A)\,\pi_d^0.$$

Since $\pi_u^u < \pi_d^u$, we have

$$\begin{aligned} [(0.5-\Delta_A)\,\pi_u^u + (0.5+\Delta_A)\,\pi_d^u]\,(0.5-\Delta_B) &< [(0.5-\Delta_A-e)\,\pi_u^u + (0.5+\Delta_A+e)\,\pi_d^u]\,(0.5-\Delta_B) \\ &= \frac{0.5-\Delta_B}{0.5+\Delta_B}\,(0.5+\Delta_A+e)\,\pi_d^0 \end{aligned}$$

where the second equality is derived from the binding constraint in (19). Therefore, the following condition is sufficient to ensure that the two aforementioned deviation strategies do not bind:

$$\frac{0.5-\Delta_B}{0.5+\Delta_B}\,(0.5+\Delta_A+e) < 0.5+\Delta_A, \tag{35}$$

which requires that e is relatively small.

Finally, the manager could also shirk and always invest in market B. To prevent the use of this deviation strategy we require that (14) dominates $0.25\left(\pi_u^u + \pi_d^u + \pi_u^d + \pi_d^d\right)$. By using the binding constraint in (19), it suffices to show the following condition:

$$\begin{aligned} & \left[1+2\Delta_A+(0.5-\Delta_A)(0.5+\Delta_B)+\frac{(0.5+\Delta_A)(0.5+\Delta_B)(0.5-\Delta_A-e)}{0.5+\Delta_A+e}\right]\pi_u^u \\ & +2\,(0.5+\Delta_A)(0.5+\Delta_B)\,\pi_d^u \geq \pi_u^u + \pi_d^u, \end{aligned}$$

which holds under the following sufficient condition

$$2\,(0.5+\Delta_A)\,(0.5+\Delta_B) > 1. \tag{36}$$

A.3 Proof of Proposition 3

Based on the least costly contract derived in Proposition 2, the expected compensation cost of implementing the two-tiered strategy is

$$\begin{aligned} K^{TT} &= 0.25\left[(1+2\Delta_A+2e)+(0.5-\Delta_A-e)\,(0.5+\Delta_B)\right]U^{-1}\left(\pi_u^u\right) \\ &\quad +0.25\,(0.5+\Delta_A+e)\,(0.5+\Delta_B)\,U^{-1}\left(\pi_d^u\right)+0.25\,(0.5+\Delta_A+e)\,U^{-1}\left(\pi_d^0\right), \end{aligned}$$

which is greater than

$$\begin{aligned} &0.25\left[(0.5+\Delta_A+e)\,(1.5-\Delta_B)\right]U^{-1}\left(\pi_u^u\right)+0.25\,(0.5+\Delta_A+e)\,(0.5+\Delta_B)\,U^{-1}\left(\pi_d^u\right) \\ &+0.25\,(0.5+\Delta_A+e)\,U^{-1}\left(\pi_d^0\right). \end{aligned} \tag{37}$$

Suppose we minimize (37) by using nonnegative π_u^u, π_d^u, and π_d^0 subject to (16). It should be clear that the minimum is lower than K^{TT}. The minimum is $\left(\frac{1}{2}+\Delta_A+e\right)\frac{3}{4}U^{-1}\left(\frac{4}{3}\frac{k}{e}\right)$, which is obtained by letting

$$\pi_u^u = \pi_d^u = \pi_d^0 = \frac{4k}{3e}.$$

Because $U^{-1}(0)=0$ and U^{-1} is convex,

$$\left(\frac{1}{2}+\Delta_A+e\right)\frac{3}{4}U^{-1}\left(\frac{4}{3}\frac{k}{e}\right) > \left(\frac{1}{2}+\Delta_A+e\right)U^{-1}\left(\frac{k}{e}\right) = K^{SM}.$$

This in turn implies that $K^{TT} > \left(\frac{1}{2}+\Delta_A+e\right)\frac{3}{4}U^{-1}\left(\frac{4}{3}\frac{k}{e}\right) > K^{SM}$.

We now show that $K^{TT}-K^{SM}$ is increasing in k. Note that in solving for the least costly contract in implementing the two-tiered strategy, (25), (26), (29), (31) and (32) have the feature that the solution $\{\pi_u^u, \pi_d^u, \pi_d^0\}$ are proportional to k, and $\{\lambda_1, \lambda_2\}$ are proportional to $k^{\frac{\alpha}{1-\alpha}}$ (note that when $U(c)=c^{1-\alpha}$, $\frac{1}{U'[U^{-1}(\pi)]} \propto \pi^{\frac{\alpha}{1-\alpha}} \propto k^{\frac{\alpha}{1-\alpha}}$). As a result, the expected cost K^{TT} is proportional to $k^{\frac{1}{1-\alpha}}$. Proposition 1 implies that the same statement also holds for K^{SM}. As a result, $K^{TT}-K^{SM}$ is proportional to $k^{\frac{1}{1-\alpha}}$. As $K^{TT}-K^{SM}$ is positive, it must be increasing with k.

A.4 Proof of Proposition 4

We first show that (23) is binding when η_C is sufficiently large. Since the left-hand side of (23) is independent of η_C while the right-hand side increases with η_C, we only need to show that there exists one value of η_C so that the least costly contract derived in Proposition 2 (which does not incorporate the constraint in (23)) violates (23). Because of the binding constraint in (16), we only need to show

$$[(1+2\Delta_A)+(0.5-\Delta_A)(0.5+\Delta_B)]\,\pi_u^u+(0.5+\Delta_A)(0.5+\Delta_B)\,\pi_d^u+(0.5+\Delta_A)\,\pi_d^0<2\eta_C\left(\pi_u^u+\pi_d^u\right).$$

Let $\eta_C=0.5+\Delta_A$. Then, we need to show that

$$(0.5-\Delta_A)(0.5+\Delta_B)\,\pi_u^u+(0.5+\Delta_A)\,\pi_d^0<(0.5+\Delta_A)(1.5-\Delta_B)\,\pi_d^u.$$

Because $\pi_u^u<\pi_d^u$ and $\pi_d^0<\pi_d^u$ in the contract, it suffices to show that

$$(0.5-\Delta_A)(0.5+\Delta_B)<(0.5+\Delta_A)(0.5-\Delta_B),$$

which holds since $\Delta_A>\Delta_B$.

To verify the second part of the proposition, we need to derive the first order conditions for deriving the least costly contract. We repeat the minimization of the total compensation cost in (20) subject to constraints in (16), (19) and (23). We denote the Lagrange multiplier of the new constraint by $\lambda_3\geq 0$. The first order conditions for the 6 payments are now given below:

$$\begin{aligned}\frac{(1+2\Delta_A+2e)+(0.5-\Delta_A-e)(0.5+\Delta_B)}{U'\left[U^{-1}\left(\pi_u^u\right)\right]} &\geq \lambda_1 e\,(1.5-\Delta_B)+\lambda_2\,(0.5-\Delta_A-e)(0.5+\Delta_B)\\ &\quad+\lambda_3\left[1+2\Delta_A+2e-2\eta_C+(0.5-\Delta_A-e)(0.5+\Delta_B)\right]\end{aligned}\tag{38}$$

with equality if $\pi_u^u>0$;

$$\begin{aligned}\frac{(0.5+\Delta_A+e)(0.5+\Delta_B)}{U'\left[U^{-1}\left(\pi_d^u\right)\right]} &\geq \lambda_1 e\,(0.5+\Delta_B)+\lambda_2\,(0.5+\Delta_A+e)(0.5+\Delta_B)\\ &\quad-\lambda_3\left[2\eta_C-(0.5+\Delta_A+e)(0.5+\Delta_B)\right]\end{aligned}\tag{39}$$

with equality if $\pi_d^u>0$;

$$\begin{aligned}\frac{(1-2\Delta_A-2e)+(0.5+\Delta_A+e)(0.5-\Delta_B)}{U'\left[U^{-1}\left(\pi_d^d\right)\right]} &\geq -\lambda_1 e\,(1.5+\Delta_B)+\lambda_2\,(0.5+\Delta_A+e)(0.5-\Delta_B)\\ &\quad+\lambda_3\left[1-2\Delta_A-2e+(0.5+\Delta_A+e)(0.5-\Delta_B)\right]\end{aligned}\tag{40}$$

with equality if $\pi_d^d>0$;

$$\begin{aligned}\frac{(0.5-\Delta_A-e)(0.5-\Delta_B)}{U'\left[U^{-1}\left(\pi_u^d\right)\right]} &\geq -\lambda_1 e\,(0.5-\Delta_B)+\lambda_2\,(0.5-\Delta_A-e)(0.5-\Delta_B)\\ &\quad+\lambda_3\,(0.5-\Delta_A-e)(0.5-\Delta_B)\end{aligned}\tag{41}$$

with equality if $\pi_u^d>0$;

$$\frac{(0.5+\Delta_A+e)}{U'\left[U^{-1}\left(\pi_d^0\right)\right]}\geq\lambda_1 e-\lambda_2\,(0.5+\Delta_A+e)+\lambda_3\,(0.5+\Delta_A+e)\tag{42}$$

with equality if $\pi_d^0 > 0$;

$$\frac{(0.5 - \Delta_A - e)}{U'\left[U^{-1}\left(\pi_u^0\right)\right]} \geq -\lambda_1 e - \lambda_2 \left(0.5 - \Delta_A - e\right) + \lambda_3 \left(0.5 - \Delta_A - e\right) \tag{43}$$

with equality if $\pi_u^0 > 0$.

By comparing (41) and (43), it is easy to show that $\pi_u^d = 0$ implies that $\pi_u^0 = 0$. This implies that we only need to compare π_d^d and π_u^d. From (40), π_d^d is positive

$$-\lambda_1 e \frac{1.5 + \Delta_B}{0.5 + \Delta_A + e} + \lambda_2 \left(0.5 - \Delta_B\right) + \lambda_3 \left(0.5 - \Delta_B\right) + \lambda_3 \frac{1 - 2\Delta_A - 2e}{0.5 + \Delta_A + e} \tag{44}$$

is positive and zero otherwise; while π_u^d is positive if

$$-\lambda_1 e \frac{0.5 - \Delta_B}{0.5 - \Delta_A - e} + \lambda_2 \left(0.5 - \Delta_B\right) + \lambda_3 \left(0.5 - \Delta_B\right) \tag{45}$$

is positive and zero otherwise. Now consider the following sufficient condition that

$$0.5 + \Delta_B < 2\Delta_A + 2e.$$

Under this sufficient condition, we have

$$\frac{1.5 + \Delta_B}{0.5 + \Delta_A + e} < \frac{0.5 - \Delta_B}{0.5 - \Delta_A - e}.$$

This implies that (44) is greater than (45), i.e., π_d^d becomes positive before π_u^d turns positive.

A.5 Proof of Proposition 5

The argument for the agency cost to be increasing with k follows the same argument in Proposition 3, which implies that the expected compensation cost is of order $k^{\frac{1}{1-\alpha}}$. Note that the derivative of the expected compensation cost with respect to η_C is $0.5\lambda_3 \left(\pi_u^u + \pi_d^u\right) \geq 0$, which is strictly positive when the constraint in (23) is binding. Therefore the expected compensation cost in the presence of tail risk increases with η_C, and as a result k^* is decreases with η_C.

B An Alternative Model Setting

In this appendix, we adopt an alternative model setting, in which the manager can invest in both markets A and B and face no short-sales constraints. We show that the key result of our main paper remains robust in this alternative setting.

The primary market A and the outside market B are specified in the same way as in the main model, except that the manager can short sell. That is to say, the manager to take either a long or short position in both markets simultaneously based on his signals s_A and s_B. We still restrict the size of the position to be one unit. There is no need for the manager to take a zero position as such a position is always dominated by either a long or short position depending on the manager's signal. This alternative setting relaxes two simplifying assumptions used in the main model—the restrictions on the manager's positions in multiple markets and short sales.

B.1 Single-Market Strategy

We first analyze the single-market strategy. Suppose that the principal implements the single market strategy, i.e., the manager takes a long (short) position of one unit in market A if $s_A = 1$ ($s_A = -1$), and always ignores his free signal on market B and takes no position outside market A. As a result, the fund performance can take two possible values $\widetilde{r}_F \in \{r, -r\}$ and the benchmark return of market A can be $\widetilde{r}_A \in \{r, -r\}$. Hence, the incentive contract specifies four possible payments:

$$\left\{\pi^{\widetilde{r}_F}_{\widetilde{r}_A}\right\} = \left\{\pi^u_u, \pi^u_d, \pi^d_u, \pi^d_d\right\}.$$

The manager's expected utility from working (i.e., exerting effort to improve his signal about market A) is

$$\begin{aligned} & \mathbb{E}\left[\overline{U}(c,\theta)\,\middle|\text{exerting effort and obtain } s^e_A\right] \\ = \; & 0.5\left[(0.5+\Delta_A+e)\,\pi^u_u + (0.5-\Delta_A-e)\,\pi^d_u + (0.5+\Delta_A+e)\,\pi^u_d + (0.5-\Delta_A-e)\,\pi^d_d\right] - k. \end{aligned}$$

For instance, the manager receives π^u_d when $r_A = -r$ (which has a probability of 0.5) and when he receives $s^e_A = -1$ (which has a conditional probability of $0.5 + \Delta_A + e$). Similarly, the manager's utility from shirking is

$$\begin{aligned} & \mathbb{E}\left[\overline{U}(c,\theta)\,\middle|\text{shirk and obtain } s^0_A\right] \\ = \; & 0.5\left[(0.5+\Delta_A)\,\pi^u_u + (0.5-\Delta_A)\,\pi^d_u + (0.5+\Delta_A)\,\pi^u_d + (0.5-\Delta_A)\,\pi^d_d\right]. \end{aligned} \tag{46}$$

Thus, the incentive constraint is $0.5\left(\pi^u_u - \pi^d_u + \pi^u_d - \pi^d_d\right) \geq k/e$. Following the same argument used in the main model, the least costly contract to implement this strategy is

$$\pi^u_u = \pi^u_d = k/e, \quad \pi^d_u = \pi^d_d = 0.$$

Furthermore, to prevent deviation, the contract pays zero if the fund delivers $\pm 2r$ which immediately reveals that the manager has invested in B. Hence, the principal's expected payoff from implementing this single-market strategy is

$$V^{SM} = 2\,(\Delta_A + e)\,r - (0.5 + \Delta_A + e)\,U^{-1}(k/e)\,. \tag{47}$$

B.2 Double-Market Strategy

We now consider implementing a so-called double-market strategy—the first-best investment strategy of taking a long position of one unit in market i ($i \in \{A, B\}$) whenever the signal $s_i = 1$ or a short position of one unit if $s_i = \square 1$. That is, the manager invests in both markets and independently determines a long or short position in each market based on his signal about the market.

Aggregating the manager's positions in the two markets leads to three possible fund return:

$$\widetilde{r}_F \in \{2r, 0, \square 2r\}.$$

When combined with the two possible returns in the primary market (which the principal observes), the incentive contract can be represented by the following six payments:

$$\left\{\pi_{\widetilde{r}_A}^{\widetilde{r}_F}\right\} = \left\{\pi_u^u, \pi_u^0, \pi_u^d, \pi_d^u, \pi_d^0, \pi_d^d\right\}.$$

With slight abuse of notation, in the superscript u refers to $\widetilde{r}_F = 2r$ and d refers to $\widetilde{r}_F = \square 2r$; while in the subscript u refers to $\widetilde{r}_A = r$ and d refers to $\widetilde{r}_A = \square r$.

We derive the manager's expected utility from working based on the following six possible payments:

1. To receive payment π_u^u, the fund return $\widetilde{r}_F = 2r$ and the primary market return $\widetilde{r}_A = r$. This is possible only if the manager take long positions in both markets, and both markets have positive returns. With probability 0.5 market A has positive return, and the manager takes a long position there with probability $0.5 + \Delta_A + e$. There are two scenarios to yield a positive return from market B: either the market B is positive (with probability 0.5) and the manager takes a long position (with probability $0.5 + \Delta_B$) or the market B is negative (with probability 0.5) but the manager takes a short position (with probability $0.5 + \Delta_B$). Taken together, the probability of receiving payment π_u^u is $0.5\,(0.5 + \Delta_A + e)\,(0.5 + \Delta_B)$.

2. To receive payment π_d^d, the fund performance return $\widetilde{r}_F = \square 2r$ and the primary market return $\widetilde{r}_A = \square r$. This is possible only if the manager take long positions in both markets, and both markets have positive returns. Similar to Case 1, the probability of receiving payment π_d^d is $0.5\,(0.5 \square \Delta_A \square e)\,(0.5 \square \Delta_B)$.

3. To receive payment π_u^0, the fund performance return $\widetilde{r}_F = 0$ and the primary market return $\widetilde{r}_A = r$ (which has probability 0.5). There are two scenarios to reach this outcome: either because the manager takes a long position in market A (with probability

$0.5 + \Delta_A + e$) and a losing position in market B (with probability $0.5 - \Delta_B$) or because the manager takes a short position in market A (with probability $0.5 - \Delta_A - e$) and a winning position in market B (with probability $0.5 + \Delta_B$). Taken together, the probability for the manager to receive this payment is

$$0.5\left[(0.5 + \Delta_A + e)(0.5 - \Delta_B) + (0.5 - \Delta_A - e)(0.5 + \Delta_B)\right] \tag{48}$$

4. Similarly, the probability for the manager to receive payment π_d^0 is
$$0.5\left[(0.5 - \Delta_A - e)(0.5 + \Delta_B) + (0.5 + \Delta_A + e)(0.5 - \Delta_B)\right].$$
5. Similarly, the probability to receive payment π_d^u is $0.5\,(0.5 + \Delta_A + e)(0.5 + \Delta_B)$.
6. Similarly, the probability to receive payment π_u^d is $0.5\,(0.5 - \Delta_A - e)(0.5 - \Delta_B)$.

Hence, the manager's expected utility from working is

$$\begin{aligned}
&0.5\left[(0.5 + \Delta_A + e)(0.5 + \Delta_B)\right]\pi_u^u + 0.5\left[(0.5 + \Delta_A + e)(0.5 + \Delta_B)\right]\pi_d^u \\
&+0.5\left[(0.5 + \Delta_A + e)(0.5 - \Delta_B) + (0.5 - \Delta_A - e)(0.5 + \Delta_B)\right]\pi_u^0 \\
&+0.5\left[(0.5 + \Delta_A + e)(0.5 - \Delta_B) + (0.5 - \Delta_A - e)(0.5 + \Delta_B)\right]\pi_d^0 \\
&+0.5\,(0.5 - \Delta_A - e)(0.5 - \Delta_B)\,\pi_d^d + 0.5\,(0.5 - \Delta_A - e)(0.5 - \Delta_B)\,\pi_u^d - k.
\end{aligned}$$

His expected utility from shirking is setting $e = 0$ in the above expression and deleting k. Thus, the incentive constraint is

$$\begin{aligned}
&0.5\,(0.5 + \Delta_B)\,\pi_u^u + 0.5\,(0.5 + \Delta_B)\,\pi_d^u \\
\geq\ & k/e + \Delta_B\pi_u^0 + \Delta_B\pi_d^0 + 0.5\,(0.5 - \Delta_B)\,\pi_d^d + 0.5\,(0.5 - \Delta_B)\,\pi_u^d
\end{aligned} \tag{49}$$

Note that for some of the outcomes, investing in market B makes the manager's good performance in the primary market unclear to the principal, and hence reduces the efficiency of incentive provision. For instance, consider payment π_u^0. The manager may have received a positive signal about the primary market and thus a good performance in his primary market position, together with a bad performance from his position in market B (due to ex post inaccurate signal s_B). Alternatively, the manager may have received a negative signal about the primary market and thus a poor performance in his primary market position, together with a good performance from his position in market B (due to ex post accurate signal s_B). Because of the offsetting performance of the manager's positions in these two markets and because of the inability for the principal to directly observe the manager's position in the primary market, the cost to incentive ratio $\left(\frac{p}{Dp}\right)_\omega$ of payment π_u^0 is negative in (49). As a result, the least costly contract gives the manager zero payment for this outcome. Like in the main model, the interfered inference of the manager's position in the primary market by his position in market B is the key driver of our result.

B.3 Optimal Contract

To show that the single-market strategy may dominate the double-market strategy, we only need to identify an upper bound of the principal's expected payoff from the double-market strategy. The upper bound is identified by assuming that the incentive constraint in (49), which only considers the deviation of shirking but still following the intended investment strategy, is the only binding constraint in solving the contract. In the main model, another deviation provides an additional binding constraint, which always lowers the principal's expected payoff.

With the incentive constraint in (49) as the only binding constraint, the least costly contract in implementing the double-market strategy is:

$$\pi_u^u = \pi_d^u = \frac{k}{e\left(0.5 + \Delta_B\right)}, \pi_u^0 = \pi_d^0 = \pi_d^d = \pi_u^d = 0,$$

and the principal's expected payoff is

$$V^{DM} = \left[2\left(\Delta_A + e\right) + 2\Delta_B\right] r - \left(0.5 + \Delta_A + e\right)\left(0.5 + \Delta_B\right) U^{-1}\left(\frac{k}{e\left(0.5 + \Delta_B\right)}\right) \tag{50}$$

That V^{SM} in (47) exceeds V^{DM} in (50) is equivalent to

$$\left(0.5 + \Delta_A + e\right)\left(0.5 + \Delta_B\right) U^{-1}\left(\frac{k}{e\left(0.5 + \Delta_B\right)}\right) - \left(0.5 + \Delta_A + e\right) U^{-1}\left(k/e\right) > 2\Delta_B r$$

Take $\alpha = 0.5$ in equation (1), then $U^{-1}\left(x\right) = x^2$. Then, the above condition is equivalent to

$$\frac{k^2}{e^2}\frac{0.5 - \Delta_B}{0.5 + \Delta_B} > \frac{2\Delta_B r}{0.5 + \Delta_A + e},$$

which easily holds when $\Delta_B \to 0$ or when k is sufficiently large. Based on the analysis above, we obtain the following proposition:

Proposition 6 *When the manager's cost of effort in his primary market is sufficiently high or when the manager's free signal about market B is sufficiently imprecise, the single-market strategy of only investing in the primary market dominates the double-market strategy of investing in both markets based on the manager's signals, even though the manager's signal about market B is nevertheless useful.*

The driver of this result works in the same way as the main model. As the principal cannot directly observe the manager's investment positions and the fund performance aggregates the manager's returns from both markets, investing in both markets impedes the principal's inference problem of the manager's effort and thus makes incentive provision more costly.

References

Acharya, V., Cooley, T., and Richardson, M., 2010. *Manufacturing Tail Risk*, Now Publishers Inc.

Admati, A. and Pfleiderer, P., 1997. Does it all add up? Benchmarks and the compensation of active portfolio managers, Journal of Business 70, 323-350.

Almazan, A., Brown, K., Carlson, M., and Chapman, D., 2004. Why constrain your mutual fund manager? Journal of Financial Economics 73, 289-321.

Bank for International Settlements, 2003. Incentive structures in institutional asset management and their implications for financial markets, Report submitted by the Committee on the Global Financial System.

Bekaert, G., Harvey, C., Lundblad, C., and Siegel, S., 2008. What segments equity markets? Working paper, Columbia University.

Berk, J., and Green, R., 2004. Mutual fund flows and performance in rational markets, Journal of Political Economy 112, 1269-1295.

Bhattacharya, S., and Pfleiderer P., 1985. Delegated portfolio management, Journal of Economic Theory 36, 1-25.

Bolton, P., Santos, T., and Scheinkman, J., 2011. Inside and outside liquidity, Quarterly Journal of Economics 126, 259-321.

Brown, K., Harlow, V., and Starks L., 1996. Of tournaments and temptations: An analysis of managerial incentives in the mutual fund industry, Journal of Finance 51, 85-110.

Brunnermeier, M., and Pedersen, L., 2009. Funding liquidity and market liquidity, Review of Financial Studies 22, 2201-2238.

Cadenillasa, A., Cvitanić, J., and Zapatero, F., 2007. Optimal risk-sharing with effort and project choice, Journal of Economic Theory 113, 403-440.

Collin-Dufresne, P., Goldstein, R., Martin, S., 2001. The determinants of credit spread changes, Journal of Finance 56, 2177-2207.

Coval, J., and Stafford, E., 2007. Asset fire sales (and purchases) in equity markets, Journal of Financial Economics 86, 479-512.

Da, Z., and Gao, P., 2008. Clientele change, persistent liquidity shock, and bond return reversal after rating downgrades, Working paper, University of Notre Dame.

Dasgupta, A., and Prat, A. 2008. Information aggregation in financial markets with career concerns, Journal of Economic Theory 143, 83-113.

Duffie, D., 2010, Asset price dynamics with slow-moving capital, Journal of Finance.

Dybvig, P., Farnsworth, H., and Carpenter, J., 2010. Portfolio performance and agency, Review of Financial Studies 23, 1-23.

Froot, K. and O'Connell, P., 1999. The pricing of US catastrophe reinsurance, in Kenneth Froot ed. The Financing of Catastrophe Risk, University of Chicago Press.

Gabaix, X., Krishnamurthy, A. and Vigneron, O., 2007. Limits of arbitrage: theory and evidence from the mortgage-backed securities market, Journal of Finance 52, 557-595.

Nicolae, G., Pedersen L., and Poteshman, A. 2009. Demand-based option pricing, Review of Financial Studies 22, 4259-4299.

Gervais, S., Lynch, A., and Musto D., 2005. Fund families as delegated monitors of money managers, Review of Financial Studies 18, 1139-1169.

Guerrieri, V., and Kondor, P., 2010. Fund managers, career concerns, and asset price volatility, forthcoming in American Economic Review.

Gromb, D., and Vayanos, D., 2002. Equilibrium and welfare in markets with financially constrained arbitrageurs, Journal of Financial Economics 66, 361-407.

He, Z., 2012. Dynamic compensation contracts with private savings, forthcoming in Review of Financial Studies.

He, Z., and Arvind Krishnamurthy A., 2012a, A model of capital and crisis, forthcoming in Review of Economic Studies.

He, Z., and Krishnamurthy A., 2012a, Intermediary asset pricing, Working paper, University of Chicago.

Heinkel, R., and Stoughton N., 1994. The dynamics of portfolio management contracts, Review of Financial Studies 7, 351-387.

Holmstrom, B., 1979. Moral hazard and observability, Rand Journal of Economics 10, 74-91.

Jame, R., 2010. Organizational structure and fund performance: pension funds vs. mutual funds, Job market paper, Emory University.

Kaniel, R. and Kondor, P., 2012. The delegated Lucas-tree, forthcoming in Review of Financial Studies.

Kostovetsky, L., 2009. Human capital flows and the financial industry, Working paper, University of Rochester.

Kyle, A. and Xiong, W., 2001. Contagion as a wealth effect, Journal of Finance 56, 1401-1440.

Lakonishok, J., Shleifer, A., and Vishny R., 1992. The impact of institutional trading on stock prices, Journal of Financial Economics 32, 23-43.

Lowenstein, R., 2000. When Genius Failed: The Rise and Fall of Long-Term Capital Management, Random House, New York.

Malliaris, S., and Yan, H., 2009. Reputation concerns and slow-moving capital, Working paper, Yale SOM.

Mamaysky, H., and Spiegel, M., 2002. A theory of mutual funds: optimal fund objectives and industry organization, Working paper, Yale University.

Makarov, I., and Plantin, G., 2010. Rewarding trading skills without inducing gambling, Working paper, LBS.

Massa, M., 2003. How do family strategies affect fund performance? When performance-maximization is not the only game in town, Journal of Financial Economics 67, 249-304.

Merton, R., 1987. A simple model of capital market equilibrium with incomplete information, Journal of Finance 42, 483-510.

Mitchell, M., Pedersen, L., and Pulvino, T., 2008. Slow moving capital, American Economic Review 97, 215-220.

Ou-Yang, H., 2003. Optimal contracts in a continuous-time delegated portfolio management problem, Review of Financial Studies 16, 173-208.

Palomino, F., and Prat, A., 2003. Risk taking and optimal contracts for money managers, Rand Journal of Economics 34, 113-137.

Philippon, T. and Reshef, A., 2008. Wages and human capital in the US financial industry: 1909-2006, Working paper, NYU Stern.

Rajan, R., 2010. Fault Lines, Princeton University Press.

Shleifer, A. and Vishny, R., 1997. Limits of arbitrage, Journal of Finance 52, 35-55.

Stein, J., 2005. Why are most funds open-end? Competition and the limits of arbitrage, Quarterly Journal of Economics 120, 247-272.

Vayanos, D., and Woolley P., 2008. An institutional theory of momentum and reversal, Working paper, LSE.