Fund managers' contracts and financial markets' short-termism[1]

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Abstract

This paper considers the problem faced by long-term investors who have to delegate the management of their money to professional fund managers. Investors can earn profits if fund managers collect long-term information. We investigate to what extent the delegation of fund management prevents long-term information acquisition, inducing short-termism in financial markets. We also study the design of long-term fund managers' compensation contracts. Under moral hazard, fund managers' compensation optimally depends on both short-term and long term fund performance. Short term performance is determined by price efficiency, and thus by subsequent fund managers' information acquisition decisions. These managers are less likely to be active on the market if information has already been acquired initially, giving rise to a feedback effect. The consequences are twofold: First, short-termism emerges. Second, short-term compensation for fund managers depends in a non-monotonic way on long-term information precision. We derive predictions regarding fund managers' contracts and financial markets efficiency.

1 Introduction

Are short-term bonuses for fund managers harmful for market efficiency? Does short term compensation prevent fund managers from taking into account the long term value of assets? This paper explores these issues and investigates the link between the time structure of fund managers mandates and market efficiency. Short-termism in financial markets is hard to reconcile with finance theory because of market efficiency: If short-term prices incorporate all available future information, the fact that agents' compensation is based on short-term prices cannot induce a short-term bias. Presumably, the only reason why short-termism could arise is because short-term prices are not efficient. In this paper we endogenize the level of market efficiency, and the corresponding fund managers' compensation contracts.

A widespread view in the financial industry is that relying on short term performance makes it harder to implement a long term strategy. For instance, a Socially Responsible Investment fund manager reports "The big difficulty is that a lot of the reputational issues and environmental issues play out over a very long period of time [...] and if the market isn't looking at it you can sit there for a very long time on your high horse saying 'this company is a disaster, it shouldn't be trusted 'and you can lose your investors an awful lot of money... ".[1] In a similar vein, to convince investors that it will generate long term value, Brevan Howard Asset Management, one of Europe's largest hedge-fund groups, has started paying its traders' annual bonuses over several years, adjusting the size of the bonus according to the fund's performance. The objective of this paper is to explore the link between short-termism and short-term based compensation in the asset management industry.

A growing body of literature shows that some pieces of information are slow to be incorporated into stock prices. For example, Edmans (2011) reports that firms included in the list of "100 Best Companies to Work For in America" earn positive abnormal returns for a period of time as long as four years after inclusion. Other studies suggest that positive abnormal long run returns are triggered by high research and development expenditures (Lev and Sougiannis (1996)), advertising expenditures (Chan, Lakonishok, and Sougiannis (2001)), patent citations (Deng, Lev, and Narin (1999)), software development costs (Aboody and Lev (1998)), corporate governance quality indexes (Gompers, Ishii, Metrick (2003)). These empirical results are often interpreted as stemming from the intangible nature of the information under study. The present paper offers an alternative hypothesis based on the long-term nature of the information under study (the information items cited above are more likely to improve long-run than short-term financial performance). Our hypothesis is that the slow incorporation of information is a result of stock market short-termism due to delegated asset management.

We consider the problem faced by long-term investors who have to delegate the management

[1] Guyatt (2006).

of their money to professional fund managers. Investors can earn profits if fund managers collect long-term information. However, information acquisition is subject to moral hazard, in the sense that fund managers have to exert an unobservable effort to increase the level of precision of their information. In this context, we determine the optimal compensation structure designed by investors for their fund managers. Doing so, we are able to investigate to what extent the delegation of fund management prevents long-term information acquisition, inducing short-termism. We are also able to study if and how compensation based on short-term prices increases short-termism.

More precisely, the model highlights two channels through which short-termism arises. Firstly, because of moral hazard, investors have to give an agency rent to fund managers: this increases the cost borne by investors to hire a fund manager. When that cost exceeds trading profits, short-termism emerges. In that case, an increase in information precision both increases trading profits and reduces the agency rent left to fund managers. For that reason, for some parameter values, short-termism decreases with information precision. Secondly, agency issues give rise to a feedback effect that worsens short-termism. Under moral hazard, long term investors optimally spread fund managers' compensation across the short run and the long run if short-term prices are efficient. However, whether short term prices are efficient is endogenous. It depends on whether subsequent fund managers acquire information, and trade according to it. And this depends on the initial information acquisition decision of fund managers. Subsequent fund managers are less likely to be present on the market if information has already been acquired initially (this is the standard Grossman-Stiglitz (1980) mechanism). Therefore, incentive costs increase if subsequent fund managers are deterred from entering the market. An interesting result is that the higher the precision of the initial information, the stronger the feedback effect is. We conclude that there is a non-monotonic relationship between information precision and short-termism. For instance, we identify cases where as information precision increases, investors renounce to hire fund managers to trade on long-term information.

The model also delivers results regarding the structure of fund managers' compensation contracts. We show that it is optimal to give a bonus to fund managers each time the fund performance is positive, and to keep this bonus constant, whatever the magnitude of the performance, and the date at which positive performance arises. The basic reason why bonuses are kept constant is that part of the positive performance is due to the presence (or not) of hedgers on the market. When realized performance is due to market movements and not to fund managers' talent or effort, it should not give rise to a bonus. Also, short term bonuses are used to allow fund managers to smooth consumption across time, and to reduce incentive costs. The optimal compensation contract can then be interpreted as an immediate cash bonus when short term performance is positive, plus a deferred bonus if long term performance remains positive. When short term performance is negative or null, fund managers only obtain a deferred bonus, conditional on long term performance. These results speak to the debate on the structure of managers' bonus in the financial service industry and are in line with the recently voted European Union Capital Requirements Directive (CRD III). The latter explicitly sets limits to bankers' cash bonuses and specifies that a substantial part of the bonus should be contingent on subsequent performance. Our mix of cash and deferred, performance contingent bonuses offers theoretical ground for these practices.

The model allows us to derive predictions regarding market efficiency and fund managers' bonus contracts. First, because there is a non-monotonic relationship between information precision and short-termism, we expect long term information to be more prevalent in markets or industries where information precision is more "extreme", either low or high. A first prediction of the model is that prices are more likely to incorporate long-term information in very well-known, or very innovative sectors, compared to standard industries. Relatedly, information precision affects the level of bonuses in the fund management industry in a non-monotonic way. In particular, our model explains why bonuses do not necessarily decrease with information precision. This implies that fund managers' bonuses are not always lower in industries where one expects precise information to be more easily available. A second prediction of the model is that short-termism should be more present when there is moral hazard between investors and fund managers. The implication of this is that in markets where delegated portfolio management is more important, prices should incorporate less long-term information, compared to markets with more proprietary trading. This prediction relies on the presumption that moral hazard problems are more easily circumvented in proprietary trading. Last, because short-termism is related to price efficiency through the feedback effect, an implication of the model is that short-termism is more present when markets are less liquid. Indeed, in illiquid markets, future informed traders' demand is more easily spotted and incorporated into prices, which discourages their entry. Anticipating this, initial investors do not enter either. The model thus predicts that long term information should be more reflected into prices in developed markets compared to less liquid emerging markets. Likewise, we would expect to see more long-term compensation for managers of long-term-oriented funds who invest in emerging markets. For instance, pension fund managers or socially responsible fund managers should receive more long term compensation when they invest in emerging markets.

Our analysis is related to the literature that determines how frictions on the market can prevent investors from trading on long-term information. If investors are impatient, Dow and Gorton (1994) show that they may renounce to acquire long-term information, because they are not sure that a future trader will be present when they have to liquidate their position. In Froot, Scharfstein, and Stein (1992), short-term traders herd on the same (potentially useless) information because they care only about short-term prices. Shleifer and Vishny (1990) also base short-termism on the reason that arbitrage in in the long-run is (exogenously) more costly than in the short-run. Holden and Subrahmanyam (1996) argue that risk averse investors do not like to hold positions for a long time when prices are volatile. And Vives (1995) considers that the rate of information arrival matters when traders have short horizons. In all of these papers, investors have exogenous limited horizon, or are risk averse and cannot contract with risk neutral agents. Having in mind the situation faced by long-term investors such as pension funds, we take a different road, and assume that investors are long-term and risk neutral. This allows us to study explicitly the delegation problem with fund managers. Guembel (2005) also studies a problem of delegation, where investors need to assess the ability of fund managers. Short-termism arises in his model because trading on short-term information, albeit less efficient, gives a more precise signal on fund managers' ability. We depart from this analysis by assuming moral hazard instead of unknown fund managers' talent. Last, our focus on the moral hazard problem between investors and fund managers is related to Gorton, He, and Huang (2009). They explore to what extent investors can use information aggregated in current market prices to incentive fund managers, and highlight that competing fund managers may have an incentive to manipulate prices, rendering markets less efficient. Instead, we focus on how investors can use future prices to incentives their managers: we thus ignore manipulation, but highlight a feedback effect that also decreases price efficiency.

The paper is organized as follows. Next section presents the model and determines the benchmark case when there is no moral hazard. Section 3 derives the main results of the paper: it solves the problem under moral hazard, and highlights the cost of delegation, and the optimal time structure of fund managers' mandates. Section 4 presents the predictions derived from the model. Last, section 5 discusses the robustness of the analysis by exploring to what extent results are affected when some assumptions are relaxed.

2 The model

We consider an exchange economy with two assets: a risk-free asset with a rate of return normalized to zero, and a risky asset. There are three dates: 1, 2, and 3. The risky asset pays off a cash-flow v at date 3. For simplicity, the cash-flow can be 1 or 0 with the same probability $\frac{1}{2}$. Trading occurs at date t with $t \in \{1, 2\}$.

2.1 The fund management industry

There are two types of agents in the fund management industry: investors and fund managers. Investors are risk-neutral. We assume that, because of time or skill constraints, investors cannot access the financial market directly. They have to hire a fund manager, referred to as a manager. We assume that one investor is born at each date t and delegates her fund management to a manager.[2] We consider that a different manager is hired at each date. Investor 1 is born at date 1 and hires manager 1, and investor 2 is born at date 2 and hires manager 2.

Managers are risk averse and have no initial wealth. The utility function of manager 1 entering the market at date 1 is:

$$V(R_1^1, R_2^1, R_3^1) = U(R_1^1) + U(R_2^1) + U(R_3^1),$$

with

$$U(0) = 0, U'(.) > 0, U''(.) < 0.$$

R_1^1, R_2^1, and R_3^1 are the revenues of manager 1 at the different dates. They are paid by investor 1.[3] Identically, the utility function of manager 2 is:

$$V(R_2^2, R_3^2) = U(R_2^2) + U(R_3^2).$$

A manager hired at date t receives a binary private signal (H or L) about the final cash flow distributed by the risky asset. The precision of the signal depends on the level of effort exerted by the manager. There are two possible levels of effort denoted by ne or e. Specifically, if the manager exerts no effort (ne), the signal is uninformative:

$$\Pr_{ne}(s_t = H|v = 1) = \Pr_{ne}(s_t = H|v = 0) = \Pr_{ne}(s_t = L|v = 1) = \Pr_{ne}(s_t = L|v = 0) = \frac{1}{2}$$

If manager t exerts effort (e), he incurs a private cost c. The precision of the signal in this case is denoted φ_t. We have:

$$\Pr_{e}(s_t = H|v = 1) = \Pr_{e}(s_t = L|v = 0) = \varphi_t, \text{ and}$$

$$\Pr_{e}(s_t = L|v = 1) = \Pr_{e}(s_t = H|v = 0) = 1 - \varphi_t.$$

To reflect the fact that effort improves signal informativeness about v, we have that $\varphi_t > \frac{1}{2}$. For simplicity, we further assume that $\varphi_2 = 1$, that is, the manager at date 2 gets a perfect signal when he exerts effort. We denote $\varphi_1 = \varphi$. We assume that signals are independent across time (conditional on v).

[2] The assumption that only one investor is born at each date is made for simplicity. As will be discussed later, our main results hold with several investors.

[3] Because fund managers have no wealth, transfers R cannot be negative.

2.2 The financial market

Our financial market is modelled after Dow and Gorton (1994). Managers interact with two types of agents: hedgers and market makers. At each trading date t, a continuum of hedgers (of mass 1) enters the market with probability $\frac{1}{2}$. At date 3, those hedgers receive an income of 0 or 1 that is perfectly negatively correlated with the risky asset cash flow. For simplicity, we assume that hedgers are infinitely risk averse. They are thus willing to hedge their position by buying $q_t^h = 1$ unit of the risky asset.[4]

Market makers are risk neutral. They compete à la Bertrand to trade the risky asset, and are present in the market from date 1 to date 3.

At each date t, trading proceeds as follows. If hired at date t, a manager submits a market order denoted by q_t^m. If born at date t, hedgers demand $q_t^h = 1$. Market makers observe the aggregate buy and sell orders separately, and execute the net order flow out of their inventory. Denote by q_t, the aggregate buy orders. Bertrand competition between market makers along with the risk neutrality assumption implies that prices for the risky asset equal the conditional expectation of the final cash flow:

$$\begin{aligned} P_1 &= E\left(v|q_1\right), \\ \text{and } P_2 &= E\left(v|q_1, q_2\right). \end{aligned}$$

The timing of our model is summarized in Figure 1. Let us now study how managers' demands are formed. Since hedgers never sell, market makers directly identify a sell order as coming from a manager. Any information that the manager has would then directly be incorporated into prices. As a result, informed managers do not find it strictly profitable to sell the asset. For the same reason, managers who want to buy submit a market order $q_t^m = q_t^h = 1$, that is, they restrict the size of their order to reduce their market impact. Consequently, equilibrium candidates are such that managers, when they are informed, demand either one or zero.

When a manager is hired at date t, the potential buying order flow is thus $q_t = 0$, $q_t = 1$, or $q_t = 2$. When $q_t = 0$, market makers infer that the manager does not want to buy the risky asset. Likewise, when $q_t = 2$, market makers understand that the manager submits an order to buy. On the contrary, when $q_t = 1$, market makers do not know if the order comes from the hedgers or from the manager. As an illustration, Figure 2 displays the price path when both managers exert effort, buy after receiving a high signal, and do not buy after receiving a low signal, and when prices are set accordingly.

[4]In general, if they are not infinitely risk averse, hedgers want to trade less than 1 unit of the asset. However, as shown by Dow and Gorton (1994), as long as they are sufficiently risk averse, hedgers want to trade a positive amount q_h. All our results hold if $q_h < 1$. In particular, the same conclusions hold if hedgers income is positively correlated with the cash flow, in which case they sell the asset to cover the risk.

Consider now that a manager is not hired at date t. In this case, the potential order flow is $q_t = 0$ or $q_t = 1$ depending on hedgers' demand. Also, market makers anticipate that only hedgers are potentially trading and the order flow is uninformative.

2.3 The fund management delegation contracts: the perfect information benchmark

Because they cannot access financial markets directly, investors hire investment managers. This delegation relationship is organized thanks to contractual arrangements. A management contract specifies the transfers from an investor to her manager. As introduced above, these transfers are R_1^1, R_2^1, and R_3^1 for manager 1 at each date 1, 2 and 3, respectively, and R_2^2 and R_3^2 for manager 2 at each date 2 and 3, respectively.

This section studies the information acquisition and investment decisions when investors can contract on the level of effort and on the signal received. This benchmark is useful to interpret the results in the next section in which managers' effort as well as the signal received are unobservable. In this benchmark, we consider the following equilibrium conjecture: investors hire managers; managers exert effort and trade $q_t^m = 1$ after receiving good news only. In addition, the first manager trades once to open his position, and holds his portfolio up to date 3.[5]

This benchmark calls for two comments. First, from investors' perspective, adequate use of information prescribes that managers invest after receiving a high signal and do nothing otherwise. Indeed, if managers were investing irrespective of the realization of the signal, investors would be better off saving the cost of information acquisition. Second, we discuss in section 5 the case in which the first manager trades at date 2, and argue that this cannot be an equilibrium strategy.

To ensure managers' participation, investors propose a compensation contract that gives managers a utility c when effort e is chosen and when managers invest appropriately.[6] It is straightforward to show that the investor proposes manager 1 transfers $R_1^1 = R_2^1 = R_3^1 = U^{-1}\left(\frac{c}{3}\right)$ such that his expected utility is equal to c. In this case, it is individually rational for the manager to accept the contract. Similarly, manager 2 obtains transfers $R_2^2 = R_3^2 = U^{-1}\left(\frac{c}{2}\right)$, and his expected utility is c.

Investors offer such a contract if their expected profit is larger than the cost of information acquisition. Let us consider first the investor at date 1. Her expected profit is equal to the expected cash-flow paid by the asset minus the expected price paid to acquire the asset, minus

[5] We associate to this equilibrium conjecture the following out-of-equilibrium beliefs. Upon observing $q_t > 1$, market makers believe that effort has been exerted and $s_t = H$ has been observed. Upon observing $q_t < 1$, market makers believe that effort has been exerted and $s_t = L$ has been observed.

[6] We assume that managers' reservation utility is zero.

her manager's expected compensation $E\left(R_{FB}^1\right) = 3U^{-1}\left(\frac{c}{3}\right)$. Market makers anticipate that manager 1 exerts effort and buys after a high signal. As illustrated in Figure 2, the distribution of the order flow is as follows: $q_1 = 2$ with probability $\frac{1}{4}$ (this event corresponds to the case in which the signal is H and in which hedgers enter), $q_1 = 1$ with probability $\frac{1}{2}$, or $q_1 = 0$ with probability $\frac{1}{4}$. Equilibrium prices in each case are $P_1 = E(v|q_1 = 2) = \varphi$, $P_1 = E(v|q_1 = 1) = \frac{1}{2}$, $P_1 = E(v|q_1 = 0) = 1 - \varphi$.

The net expected profit of investor 1 is written:

$$\begin{aligned} E(\pi_1) &= \Pr(s_1 = H)\left[E(v|s_1 = H) - E(P_1|s_1 = H)\right] - E\left(R_{FB}^1\right) \\ &= \frac{1}{2} \times \left[\varphi - \left(\frac{1}{2} \times \varphi + \frac{1}{2} \times \frac{1}{2}\right)\right] - E\left(R_{FB}^1\right) \\ &= \frac{2\varphi - 1}{8} - E\left(R_{FB}^1\right). \end{aligned}$$

If manager 1's effort and signal can be contracted upon, investor 1 decides to hire a fund manager if and only if:

$$E(\pi_1) \geq 0 \Leftrightarrow \varphi \geq \varphi^{FB} = \frac{1}{2} + 4E\left(R_{FB}^1\right).$$

Let us consider next the investor at date 2. Her net expected profit is written:

$$E(\pi_2|P_1) = \Pr(s_2 = H|P_1)\left[E(v|P_1, s_2 = H) - E(P_2|P_1, s_2 = H)\right] - E\left(R_{FB}^2\right),$$

where $E\left(R_{FB}^2\right) = 2U^{-1}\left(\frac{c}{2}\right)$ is manager 2's expected compensation. Given that manager 2's signal is perfect, prices set by market makers according to the observed order flow are:

$$\begin{aligned} P_2(P_1, q_2 = 2) &= 1 \\ P_2(P_1, q_2 = 1) &= P_1 \\ P_2(P_1, q_2 = 0) &= 0 \end{aligned}$$

Note that $\Pr(s_2 = H|P_1) = \Pr(v = 1|P_1) = P_1$ and $E(P_2|P_1, s_2 = H) = \frac{1}{2} \times 1 + \frac{1}{2} \times P_1$. This leads to:

$$E(\pi_2|P_1) = \frac{1}{2}P_1(1 - P_1) - E\left(R_{FB}^2\right).$$

As a result, it is individually rational for investor 2 to propose the contract if and only if $E\left(R_{FB}^2\right) \leq \frac{1}{2}P_1(1 - P_1)$, that is, $P_1 \in \left[\underline{\beta}^{FB}, \overline{\beta}^{FB}\right]$ with $\underline{\beta}^{FB} = \frac{1}{2} - \frac{\sqrt{1-8E\left(R_{FB}^2\right)}}{2}$ and $\overline{\beta}^{FB} = \frac{1}{2} + \frac{\sqrt{1-8E\left(R_{FB}^2\right)}}{2}$. We assume that this interval exists, that is $E\left(R_{FB}^2\right) \leq \frac{1}{8}$.

At equilibrium, investor 1's profit increases with manager 1's information precision (φ). This precision has to be high enough for investor to recoup the cost of information acquisition. Also, investor 2's profit depends on investor 1's decision: when prices incorporate manager 1's information, the profit that investor 2 can obtain is reduced. This effect is stronger the more precise manager 1's information is (see, for example, Grossman and Stiglitz, 1980). These are standard effects of trading under asymmetric information. In addition, investor 1's equilibrium profit does not depend on investor 2's decision. This is because i) investor 1 holds her portfolio until date 3 when dividends are realized, and ii) manager 1's compensation does not depend on interim prices.

3 Fund management contract at date 1

We now investigate the case in which, at date 1, the investor cannot observe whether her manager has exerted effort nor what signal was obtained. There is thus moral hazard at the information acquisition stage and asymmetric information at the trading decision stage.[7] We do consider however that the fund management contract can be contingent on manager's trading positions. The contract is designed to provide the manager with the incentives to appropriately exert effort and trade, taking into account that he acts in his own best interest. Fund management contracts thus include two types of incentive constraints: one type is dedicated to the effort problem while the other is dedicated to the signal and trading problem.

In order to provide adequate incentives, investor 1 bases transfers on the trading position opened by her manager (q_1^m) and on the different prices that are realized at each date. Hence, investor 1 proposes the contract $\left[R_1^1\left(q_1^m\right), R_2^1\left(q_1^m, P_1, P_2\right), R_3^1\left(q_1^m, P_1, P_2, v\right)\right]$. P_1 is included in the contract proposed to manager 1 because investor 1 uses the information content of P_2 relative to P_1 to provide incentives.

We are looking for delegation contracts that provide managers incentive to exert effort and to invest only when they receive a good signal.[8] Contracts have thus to fulfill several conditions that are explicitly given below: the incentive compatibility constraints ensuring that managers are trading appropriately given that they exert effort (constraints IC_H and IC_L), and the incentive compatibility constraint ensuring that managers are exerting effort (constraint IC_e). Also, to write these constraints, we need to know what managers do when they are not exerting effort. There are two possibilities. Under constraint H_1, managers prefer to invest rather than not to invest. Under constraint H_0, managers prefer not to invest. To derive the optimal contract, we work with H_1. We then show that the results are the same if we impose constraint H_0 instead

[7]The assumption of asymmetric information is imposed to capture some realistic features of the asset management industry. However, from a theoretical point of view, we show later that it does not induce an additional incentive cost compared to the moral hazard problem.

[8]As discussed in the previous section, there is no equilibrium (even without moral hazard) where investor 1 finds it profitable to trade at date 2. Besides, it is straightforward to see that there is no equilibrium where managers buy after a low signal and do not trade after a good signal, or where trading is independent of signals.

of H_1.

3.1 Characterization of the optimal fund management contract

Assume for now that investors can contract on managers' consumption at each date, that is, there are no private savings. In our framework managers' ability to privately save would not affect the optimal contract. We discuss this point in section 3.3 in which we investigate the time structure of managers' contracts. The incentive constraints related to trading are the following:

$$\begin{aligned} \left(IC_H^1\right) &: E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)|s_1=H\right) \geq E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=0\right)\right)|s_1=H\right) \\ &\text{and} \\ \left(IC_L^1\right) &: E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=0\right)\right)|s_1=L\right) \geq E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)|s_1=L\right). \end{aligned}$$

Since the manager's compensation depends on the random variables P_1, P_2, and v, $E_e(.)$ refers to the expectation operator that uses the distribution of these variables under effort conditional on the signal received and the trading decision. These distributions are presented in Figure 2 for the case in which manager 1 plays the equilibrium strategy. When the manager deviates, prices are set according to market makers' equilibrium beliefs but the distribution of random variables is affected by the deviation. For instance, if manager 1 does not trade after $s_1 = H$, the probability to observe $P_1 = \varphi$ is zero while it is strictly positive when manager 1 does not deviate. $\left(IC_H^1\right)$ indicates that, upon exerting effort and receiving a high signal, manager 1 prefers buying than doing nothing. $\left(IC_L^1\right)$ indicates that, upon exerting effort and receiving a low signal, manager 1 prefers doing nothing than buying.

The incentive constraint that ensures that manager 1 exerts effort is:

$$\begin{aligned} \left(IC_e^1\right)\ \Pr_e\left(s_1=H\right)\left[E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)|s_1=H\right)\right] + \Pr_e\left(s_1=L\right)\left[E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=0\right)\right)|s_1=L\right)\right] - c \\ \geq\ E_{ne}\left[\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)\right]. \end{aligned}$$

This constraint indicates that manager 1's expected utility has to be greater when he exerts effort and trades appropriately (left handside of the inequality) than when he exerts no effort and always invests (right handside of the inequality). In order to write down this constraint, we work under the assumption that the manager always prefers to invest when he does not exert effort. This assumption is captured by:

$$\left(H_1^1\right): E_{ne}\left[\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)\right] \geq E_{ne}\left[\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=0\right)\right)\right].$$

Investor 1 knows that, in order to induce her manager to exert effort and trade appropriately, these four constraints need to be satisfied (along with the positive compensation constraint). Given that they are indeed satisfied, she chooses the transfers that maximize her expected profit expressed as follows:

$$E\left(\pi_1\right)=\Pr_e\left(s_1=H\right)\left[E_e\left(v \mid s_1=H\right)-E_e\left(P_1 \mid s_1=H\right)\right]-E_e\left[\sum_{t=1}^{t=3} R_t^1\left(q_1^m\right)\right].$$

As in the benchmark, Investor 1's expected profit depends on the expected dividend, the expected purchase price of the asset, and the expected managerial compensation. Given the above program, the expected compensation of the fund manager has the following properties.

Proposition 1 *The optimal contract at date 1 that induces effort and buying upon receiving a high signal verifies:*

$$\begin{aligned}
& E_e\left(U\left[R_2^1\left(q_1^m=1, P_1, P_2=1\right)\right]+U\left[R_3^1\left(q_1^m=1, P_1, P_2, v=1\right)\right]\right) \\
= \; & E_e\left(U\left[R_2^1\left(q_1^m=0, P_1, P_2=0\right)\right]+U\left[R_3^1\left(q_1^m=0, P_1, P_2, v=0\right)\right]\right) \\
= \; & \frac{\varphi c}{2\varphi-1},
\end{aligned}$$

and all other transfers are null.

The optimal contract has to provide two types of incentives. First, it must induce the manager to exert effort and to gather useful information. Second, it must induce the manager to trade appropriately according to this information. Both incentive problems can be addressed together. To be induced to exert effort, the fund manager has to be rewarded in those states that are informative of his effort. For example, when the manager exerts effort, it is more likely to get the high dividend $v=1$ after a good signal. As reflected in Proposition 1, rewarding the fund manager when he buys ($q_1^m=1$) and the final dividend is $v=1$ provides adequate incentives to exert effort and trade appropriately. Similarly, when the interim price P_2 contains information on the dividend, it is potentially optimal to use it as a compensation basis: the manager is thus rewarded when he buys and the interim price is $P_2=1$. The same arguments apply for the case where the manager receives a low signal and is induced not to trade ($q_1^m=0$). He is then rewarded when the final dividend is low ($v=0$) and/or the interim price is low ($P_2=0$). In the remainder of the paper, we refer to those states as the incentive compatible states. Proposition 1 also indicates that transfers in all other states of nature are zero. This can happen for two reasons. First, some states of nature provide no information about manager's effort. This is, for example, the case when the interim price provides no additional information compared to the initial price ($P_2 = P_1$). Second, in some so-called adverse states of nature, the non-negative compensation constraint is binding. This is the case when the state of nature reveals negative information regarding manager's effort (e.g., when $q_1^m = 1$ and $v = 0$). If negative payments could be imposed, the manager would optimally be punished with a negative utility. The assumption that the fund manager is cash-poor simply puts a lower bound on investor's ability to punish the fund manager. If the fund manager had some initial wealth, it would then be optimal to ask him to pledge some collateral that could be seized by the investor in adverse states. This would provide higher-powered incentives to the fund manager.

Manager's expected utility under moral hazard is greater than when investors can contract on the level of effort. This is stated in the following corollary.

Corollary 1 *Manager 1's agency rent is equal to* $\frac{c}{2\varphi-1}$.

The rent depends positively on the cost of effort c and negatively on the informativeness of the signal φ. The term $2\varphi - 1$ reflects the increase in the probability of being rewarded when the manager exerts effort compared to the case in which he does not exert effort.

We now investigate further the role of the interim price P_2 in the provision of incentives to manager 1. Proposition 1 indicates that P_2 is potentially useful when it reveals additional information on the final dividend value.[9] A natural question is when the investor finds it useful to base the contract on the interim price or on the final dividend. When P_2 is informative, it perfectly reveals the final dividend: both are thus equivalent from an incentive point of view (see Holmstrom, 1979). However, the investor may find it beneficial to pay at both dates in order to smooth manager's consumption as is studied below. Because of manager's risk aversion, this minimizes the cost of fund manager's compensation borne by the investor.

3.2 Cost of delegation

The previous section determines what rent has to be left to the manager in order to provide incentives. We now study what is the cost for the investor to offer such a rent, that is, the optimal expected bonus. The optimal contract depends on the level of efficiency of the interim price. Investor 1 has thus to anticipate investor 2's equilibrium behavior. Price P_2 is informative only if manager 2 is trading on valuable information, that is, if he is actually offered an incentive contract by investor 2. We assume at this stage that investor 2 enters the market if the price P_1

[9] Recall that, in our model, P_2 contains additional information when it is equal to 1 or 0, and is uninformative when it is equal to P_1.

is not too efficient, that is, if $P_1 \in \left[\underline{\beta}, \overline{\beta}\right]$ where this interval is symmetric around $\frac{1}{2}$. For example, the previous section shows that, without moral hazard at date 2, $\overline{\beta} = \overline{\beta}^{FB}$ and $\underline{\beta} = \underline{\beta}^{FB}$.[10] We have two cases to consider: when $\varphi \leq \overline{\beta}$, investor 2 hires a fund manager for all realizations of the price P_1. When $\varphi > \overline{\beta}$, investor 2 hires a fund manager only if the initial price contains no information, that is, if price $P_1 = \frac{1}{2}$. The next proposition investigates how the cost of delegation varies with the level of φ.

Proposition 2 *When $\varphi \leq \overline{\beta}$ (manager 2 is always offered an incentive contract), manager 1's expected bonus $E\left(R^1_{\varphi \leq \overline{\beta}}\right)$ is equal to $\frac{3}{2}\varphi U^{-1}\left(\frac{4c}{3(2\varphi - 1)}\right)$.*

When $\varphi > \overline{\beta}$ (manager 2 is offered an incentive contract only when $P_1 = \frac{1}{2}$), manager 1's expected bonus $E\left(R^1_{\varphi > \overline{\beta}}\right)$ is equal to $\frac{5}{4}\varphi U^{-1}\left(\frac{8c}{5(2\varphi - 1)}\right)$.

The expected bonus functions have the following properties:

$$\begin{array}{ll} i) & E\left(R^1_{\varphi \leq \overline{\beta}}\right) < E\left(R^1_{\varphi > \overline{\beta}}\right),\ \forall \varphi \in \left(\frac{1}{2}, 1\right) \\ ii) & E\left(R^1_{\varphi \leq \overline{\beta}}\right) \text{ and } E\left(R^1_{\varphi > \overline{\beta}}\right) \text{ decrease with } \varphi. \end{array}$$

Proposition 2 shows that the expected bonus function changes when $\varphi \leq \overline{\beta}$ and when $\varphi > \overline{\beta}$. This reflects the fact that when $\varphi \leq \overline{\beta}$, the price P_2 is more efficient because manager 2 is always hired. Manager 2 trades on his information for any level of the price P_1. In turn, states of the world informative about manager 1's effort occur more frequently. The investor uses these incentive compatible states to design the incentive contract. This enables her to better trade off consumption smoothing and incentive provision. As shown in property *i*), the expected bonus function jumps from $E\left(R^1_{\varphi \leq \overline{\beta}}\right)$ to $E\left(R^1_{\varphi > \overline{\beta}}\right)$ when φ moves above $\overline{\beta}$. Property *ii*) further shows that, except at $\varphi = \overline{\beta}$, the expected bonus decreases with φ. This is because, when information is more precise, incentive compatible states are more suggestive of a high effort.

The investor compares this expected bonus to the expected gross trading profits in order to determine whether she wants to hire a manager. The hiring decisions are stated in the following corollary which illustrates the impact of moral hazard on long-term information acquisition.

Corollary 2 *When $\varphi \leq \overline{\beta}$, investor 1 hires a fund manager (and long-term information is acquired) if and only if $\varphi > \varphi^* > \varphi^{FB}$. When $\varphi > \overline{\beta}$, investor 1 hires a fund manager (and long-term information is acquired) if and only if $\varphi > \varphi^{**} > \varphi^*$.*

This corollary shows that moral hazard creates short-termism, in the sense that long-term information is not acquired while it would be under perfect information. Figure 3 illustrates the

[10] Using the methodology developed in the appendix, one can easily derive these bounds when there is moral hazard between investor 2 and her fund manager.

main findings of the corollary. Short-termism arises because of two effects. The direct effect of moral hazard is that it increases the cost of information acquisition (the manager earns a rent). In turn, investor 1 requires higher trading profits to hire a fund manager. To increase profits, she thus requires higher information precision ($\varphi^* > \varphi^{FB}$). There is also an indirect effect of moral hazard. The cost of incentive provision borne by investor 1 depends on the informed trading activity of manager 2. In particular, the presence of manager 2 creates a positive externality for investor 1 in the sense that it reduces the expected bonus and therefore the threshold above which information is acquired ($\varphi^* < \varphi^{**}$). This effect is not present in the perfect information benchmark: investor 1's decision is independent from manager 2's behavior because manager 1 can be paid in any state of nature (regardless of price P_2 informational efficiency).

A natural question is whether increasing information precision always reduces short-termism. This is not necessarily the case in our model, because of the externality of manager 2's trading. As shown in proposition 2, information precision has an ambiguous impact on the expected bonus. On the one hand, the expected bonus functions decrease with φ. On the other hand, the expected bonus jumps upward at $\varphi = \overline{\beta}$. It is thus conceivable that increasing φ prevents investor 1 from hiring a manager. This is actually the case when $\varphi^* < \overline{\beta} < \varphi^{**}$ (see Panels B and C), but not when $\varphi^* < \varphi^{**} < \overline{\beta}$ (see Panel A). When $\varphi^* < \overline{\beta} < \varphi^{**} < 1$ (Panel B), investor 1 hires a manager when $\varphi^* \leq \varphi \leq \overline{\beta}$ but not when $\overline{\beta} \leq \varphi < \varphi^{**}$. In Panel C, $\varphi^{**} > 1$, short-termism is extreme: when $\varphi > \overline{\beta}$, the fund manager is never hired and no long term information is acquired.

These results complement the analysis of Dow and Gorton (1994) that suggests that the arbitrage chain which induces long-term information to be incorporated in prices, might break. Our model highlights that the arbitrage chain might break because of a feedback effect across successive managers' contracts. Investor 1 needs investor 2 to provide incentive to her manager, but if she does so, investor 2 does not (always) hire a fund manager. In turn, this can discourage investor 1 to offer an incentive contract, and no long-term information is incorporated into prices.

3.3 The structure of fund managers' compensation

We now explore how fund managers' compensation varies with the fund performance, and is structured over time. We define short term performance as the return $(2\mathbb{1}_{q_1^m=1}-1)(P_2-P_1)$ and long term performance as $(2\mathbb{1}_{q_1^m=1}-1)(v-P_1)$. The dummy $\mathbb{1}_{q_1^m=1}$ equals one if manager 1 buys one unit of asset, and zero otherwise. Performance is relative to the riskfree return (normalized to zero), which is the appropriate benchmark for risk neutral investors. Recall from Proposition 1 that manager 1 is optimally rewarded if he trades and the interim price (or the final cash-flow) is 1. If he does not trade, he is rewarded when the interim price (or the final cash-flow) is 0. The next proposition illustrates how the fund manager's compensation varies with fund performance.

Proposition 3 *The manager is awarded the same bonus after any positive short-term or long term performance.*

Proposition 3 states that the fund manager's bonus remains constant whatever the level of the portfolio performance, and whatever the time at which positive performance materializes. Firstly, as long as performance is positive, the level of portfolio performance does no affect the bonus because it is beyond manager 1's control. Indeed, portfolio performance is not very high if manager 1's information is incorporated into the initial trading price P_1, that is if hedgers trade in the same direction as the manager. Portfolio performance is higher when manager 1's trade is not revealed into price P_1. Since price P_1 efficiency depends on hedgers' demands, manager 1 should not be punished or rewarded according to the magnitude of positive performance. Our model thus provides a setting in which caps on managers' compensation naturally arise.

Secondly, all incentive compatible states (at date 2 or 3) are equally informative about managerial effort. Therefore the same bonus is offered whether positive performance accrues in the short term or in the long term. One can interpret the optimal contract as follows. When short term performance is positive, manager 1 receives an immediate cash bonus, plus a deferred bonus if long term performance remains positive. When short term performance is negative or null, manager 1 only receives the deferred bonus, conditional on long term performance. Thus, consumption smoothing and incentive issues combine to give rise to cash and deferred performance sensitive bonuses.

Our results on the compensation contract structure would be the same if manager 1 could privately save. When manager 1 receives a bonus at date 2, he knows that he will receive the same bonus with probability 1 at date 3: marginal utilities are equal across dates, and there is no incentive to save to smooth consumption. In a more general model in which incentive compatible states (at date 2 or 3) are not equally informative about managerial effort, the bonus size would vary with states' informativeness (but not with the level of efficiency of price P_1). In that case, the possibility of private savings would introduce an additional constraint to the optimal contract reflecting the fact that marginal utilities should be equal across states.

The results of Proposition 3 speak to the debate on the structure of managers' bonus in the financial service industry. The recently voted European Union Capital Requirements Directive (CRD III) explicitly sets limits to bankers' cash bonuses. In our model, we show that bonuses are capped to reflect the idea that some of the realized performance is due to market movements rather than managerial talent or effort. CRD III also specifies that a substantial part of the bonus should be contingent on subsequent performance. Our mix of cash and deferred, performance contingent bonuses offers theoretical ground for these new regulatory practices.

The next proposition explores to what extent the compensation contract is based on long-term or short-term performance.

Proposition 4 *The proportion of long-term expected compensation is higher when $\varphi \geq \overline{\beta}$ than when $\varphi < \overline{\beta}$.*

Proposition 4 states that the time structure of manager 1's mandate depends on date 2 price efficiency. The proportion of long-term expected compensation depends on the proportion of incentive compatible states available at dates 2 and 3. When $\varphi \geq \overline{\beta}$, less information is acquired by manager 2, and less incentive compatible states are available. Investor 1's optimal response is to increase the proportion of long term bonuses.

In our model, the only reason why time structure of mandates matters relies on the consumption smoothing-incentive trade-off. Relaxing some assumptions of the model provides additional insights on the optimal compensation timing. Suppose first that manager 1 exhibits impatience in the sense that for a given level of consumption, he prefers to consume at date 2 than at date 3. This necessarily shifts his compensation towards more short-term bonus. Suppose alternatively that the precision of manager 2's information is not perfect. The final cash-flow v is then a sufficient statistic of manager 1's effort. This shifts his compensation towards more long-term bonus. The optimal time structure thus trades-off the benefit of short-term compensation to cope with manager 1's impatience, and the benefit of long-term compensation to improve incentives.

Note however that risk aversion is a necessary condition for a mix of long term and short term compensation to arise. Were manager 1 risk neutral, one incentive compatible state would suffice. The optimal compensation scheme could entail payment at date 2 or at date 3 only and the feed back effect across managers' contracts would not be present.

4 Empirical implications

The results presented above allow us to derive a number of empirical implications according to the level of information precision, the extent of moral hazard, and the level of market liquidity.

First, there is a non-monotonic relationship between long-term information acquisition and information precision φ because the incentive cost of long term information acquisition jumps when φ crosses the threshold $\overline{\beta}$. We thus expect long term information to be more prevalent in markets or industries where information precision is more "extreme", either low and high. A first prediction of the model is that prices are more likely to incorporate long-term information in very well-known, or very innovative sectors, compared to standard industries.

Relatedly, information precision affects the level of bonuses in the fund management industry in a non-monotonic way. In particular, our model explains why bonuses do not necessarily decrease with information precision. This implies that fund managers' bonuses are not always lower in industries where one expects precise information to be more easily available. However, the model predicts that the proportion of long-term bonus should be higher.

Second, an insight of the paper is that moral hazard creates short-termism. A natural implication of this is that short-termism should be more pregnant in markets where delegated portfolio management has a larger market share. In particular, prices should incorporate more long-term information when there is more proprietary trading, to the extent that moral hazard problems are more easily circumvented in proprietary trading.

The fact that there is more short-termism does not a priory imply that prices are less efficient at all dates: when long term information acquisition is precluded, prices are less efficient at date 1, but this can increase informed trading at date 2. If information precision increases with time, this implies that overall market efficiency might increase with short-termism. However, it is easy to see that this is not true in our model. Indeed short-termism enhances future informed trading when φ is rather large. This is the case in which information precision does not increase much with time.We thus expect price efficiency to be negatively correlated with the prevalence of delegated portfolio management.

Third, the results of our model enable us to study the impact of market liquidity on the production of long term information. In the model, short-termism is related to the existence of a feedback effect between successive managers' contracts. This feedback effect is affected by market liquidity. When markets are very illiquid (e.g. when hedgers are less likely to be present on the market), informed traders are easily spotted, which annihilates their potential profits. If information is costly, illiquid markets deter information acquisition. If investors anticipate at date 1 that market liquidity will deteriorate, they refrain from inducing long term information acquisition, thereby worsening short-termism. An implication of the model is that short-termism is more present when markets are less liquid. To test this prediction, on could study whether long term information is more reflected into prices in developed markets compared to less liquid emerging markets. Likewise, we would expect to see more long-term compensation for managers who invest in emerging markets. For instance, pension fund managers or socially responsible fund managers should receive more long term compensation when they invest in emerging markets, compared to more liquid markets.

5 Robustness

This section explores the robustness of the main assumptions of the model.

First, there is only one pair investor/manager per period. If this was not the case, our results would still hold as long as there is imperfect competition and thus non-null trading profits. Note however that in this case, investors can use the current price to extract information on the effort made by her manager (see Gorton, He, and Huang 2009).

Second, agents are long-lived. If agents were short-lived, we would be back to Dow and Gorton (1994) that show that asymmetric information might not be incorporated into asset prices despite the existence of a chain of successive traders.

Third, investors cannot coordinate their investment policies. In our setting coordination would be useful for investor 1 to compensate investor 2 when $\varphi > \beta^*$, in order to avoid a sharp increase in the expected transfer.

Fourth, manager 1 cannot buy again at date 2 after buying at date 1. This assumption does not affect our results. Indeed, if price P_1 reveals manager 1's information, there is no expected profit left for him. If $P_1 = \frac{1}{2}$, he anticipates that, if $v = 1$, manager 2 knows it and buys. Therefore, the total demand if manager 1 buys again is 2 or 3. The market maker thus infers that there has been at least one high signal and sets a price strictly greater than φ which eliminates any expected profit for manager 1. When $v = 0$, manager 2 knows it and does not buy. If manager 1 buys again at date 2, the total demand is either 1 or 2. When the demand is 2, the price is greater than φ for the reason explained above. When the demand is 1, market maker is not aware of the fact that $v = 0$, the price is strictly greater than 0 and manager 1 loses money (he would be subject to the winner's curse). Overall, at equilibrium, manager 1 cannot trade twice on a high signal.

Fifth, market makers observe buying and selling order flows separately. If this was not the case, managers at equilibrium would not buy after a high signal *and* sell after a low signal. Indeed, their trading would always be identified and prices would be fully revealing. No profit could ever be made. The equilibrium strategies would be either to refrain from selling after a low signal (as it is the case in our equilibrium) or to refrain from buying after a high signal (our logic would still hold in this case). This assumption is simply helpful to focus on one equilibrium.

Appendix

Proof of proposition 1

The investor's objective is to minimize the fund manager's expected bonus subject to the constraints $\left(IC_H^1\right)$, $\left(IC_L^1\right)$, $\left(IC_e^1\right)$ and $\left(H_1^1\right)$ defined in section 3.1 page 10. Recall that the optimal contract determines the sequence of transfers to the fund manager $\left[R_1^1\left(q_1^m\right), R_2^1\left(q_1^m, P_1, P_2\right), R_3^1\left(q_1^m, P_1, P_2, v\right)\right]$ according to the price path. To characterize the optimal contract we use a standard Lagrangian technique. Assume first that $\varphi \leq \overline{\beta}$. The investor's program is:

$$\min_{R^1} \Pr\left(s_1 = H|e\right)\left[\begin{array}{c} R_1^1(1) + \frac{1}{4}\varphi\sum_{P_1\in\left\{\frac{1}{2},\varphi\right\}}\left[R_2^1\left(1,P_1,1\right) + \sum_{P_2\in\left\{P_1,1\right\}} R_3^1\left(1,P_1,P_2,1\right)\right] + \frac{1}{4}\left[R_2^1\left(1,\varphi,\varphi\right) + \right.\\ \left. R_2^1\left(1,\frac{1}{2},\frac{1}{2}\right)\right] + \frac{1}{4}\left(1-\varphi\right)\sum_{P_1\in\left\{\frac{1}{2},\varphi\right\}}\left[R_2^1\left(1,P_1,0\right) + \sum_{P_2\in\left\{0,P_1\right\}} R_3^1\left(1,P_1,P_2,0\right)\right] \end{array}\right]$$

$$+\Pr\left(s_1 = L|e\right)\left[\begin{array}{c} R_1^1(0) + \frac{1}{4}\varphi\sum_{P_1\in\left\{1-\varphi,\frac{1}{2}\right\}}\left[R_2^1\left(0,P_1,0\right) + \sum_{P_2\in\left\{0,P_1\right\}} R_3^1\left(0,P_1,P_2,0\right)\right] + \frac{1}{4}\left[R_2^1\left(0,1-\varphi,1-\varphi\right) + \right.\\ \left. R_2^1\left(0,\frac{1}{2},\frac{1}{2}\right)\right] + \frac{1}{4}\left(1-\varphi\right)\sum_{P_1\in\left\{1-\varphi,\frac{1}{2}\right\}}\left[R_2^1\left(0,P_1,1\right) + \sum_{P_2\in\left\{P_1,1\right\}} R_3^1\left(0,P_1,P_2,1\right)\right] \end{array}\right],$$

subject to:

$$\begin{aligned}\left(IC_H^1\right)\quad E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)|s_1=H\right) \geq{}& \frac{1}{4}\varphi\sum_{P_1\in\left\{1-\varphi,\frac{1}{2}\right\}}\left(U\left[R_2^1\left(0,P_1,1\right)\right] + \sum_{P_2\in\left\{P_1,1\right\}} U\left[R_3^1\left(0,P_1,P_2,1\right)\right]\right)\\ &+U\left[R_1^1(0)\right] + \frac{1}{4}\left(U\left[R_2^1\left(0,1-\varphi,1-\varphi\right)\right] + U\left[R_2^1\left(0,\frac{1}{2},\frac{1}{2}\right)\right]\right)\\ &+\frac{1}{4}\left(1-\varphi\right)\sum_{P_1\in\left\{1-\varphi,\frac{1}{2}\right\}}\left(U\left[R_2^1\left(0,P_1,0\right)\right] + \sum_{P_2\in\left\{0,P_1\right\}} U\left[R_3^1\left(0,P_1,P_2,0\right)\right]\right),\end{aligned}$$

$$\begin{aligned}\left(IC_L^1\right)\quad E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=0\right)\right)|s_1=L\right) \geq{}& \frac{1}{4}\varphi\sum_{P_1\in\left\{\frac{1}{2},\varphi\right\}}\left(U\left[R_2^1\left(1,P_1,0\right)\right] + \sum_{P_2\in\left\{0,P_1\right\}} U\left[R_3^1\left(1,P_1,P_2,0\right)\right]\right)\\ &+U\left[R_1^1(1)\right] + \frac{1}{4}\left[U\left[R_2^1\left(1,\varphi,\varphi\right)\right] + U\left[R_2^1\left(1,\frac{1}{2},\frac{1}{2}\right)\right]\right]\\ &+\frac{1}{4}\left(1-\varphi\right)\sum_{P_1\in\left\{\frac{1}{2},\varphi\right\}}\left(U\left[R_2^1\left(1,P_1,1\right)\right] + \sum_{P_2\in\left\{P_1,1\right\}} U\left[R_3^1\left(1,P_1,P_2,1\right)\right]\right),\end{aligned}$$

$$\left(H_1^1\right) \;\; U\left[R_1^1(1)\right]+\frac{1}{8}\left(\sum_{P_1\in\left\{\frac{1}{2},\varphi\right\}}\sum_{P_2\in\{0,1\}}U\left[R_2^1(1,P_1,P_2)\right]+\sum_{P_1\in\left\{\frac{1}{2},\varphi\right\}}\sum_{P_2\in\{P_1,v\}}\sum_{v\in\{0,1\}}U\left[R_3^1(1,P_1,P_2,v)\right]\right)$$

$$+\frac{1}{4}\left(\sum_{P_1\in\left\{\frac{1}{2},\varphi\right\}}\sum_{P_2=P_1}U\left[R_2^1(1,P_1,P_2)\right]\right)\geq$$

$$U\left[R_1^1(0)\right]+\frac{1}{8}\left(\sum_{P_1\in\left\{1-\varphi,\frac{1}{2}\right\}}\sum_{P_2\in\{0,1\}}U\left[R_2^1(0,P_1,P_2)\right]+\sum_{P_1\in\left\{1-\varphi,\frac{1}{2}\right\}}\sum_{P_2\in\{P_1,v\}}\sum_{v\in\{0,1\}}U\left[R_3^1(0,P_1,P_2,v)\right]\right)$$

$$+\frac{1}{4}\left(\sum_{P_1\in\left\{1-\varphi,\frac{1}{2}\right\}}\sum_{P_2=P_1}U\left[R_2^1(0,P_1,P_2)\right]\right)$$

where $E_e\left(\sum_{t=1}^{t=3}U\left(R_t^1\left(q_1^m=1\right)\right)|s_1=H\right)$ (resp., $E_e\left(\sum_{t=1}^{t=3}U\left(R_t^1\left(q_1^m=0\right)\right)|s_1=L\right)$) is computed using the probability distribution indicated in the objective function.when $s_1=H$ (resp., $s_1=L$);

$$\left(IC_e^1\right) \;\; \Pr(s_1=H|e)\left[E_e\left(\sum_{t=1}^{t=3}U\left(R_t^1\left(q_1^m=1\right)\right)|s_1=H\right)\right]+\Pr(s_1=L|e)\left[E_e\left(\sum_{t=1}^{t=3}U\left(R_t^1\left(q_1^m=0\right)\right)|s_1=L\right)\right]-c$$

$$\geq E_{ne}\left[\sum_{t=1}^{t=3}U\left(R_t^1\left(q_1^m=1\right)\right)\right],$$

where $E_{ne}\left[\sum_{t=1}^{t=3}U\left(R_t^1\left(q_1^m=1\right)\right)\right]$ is the left-hand side of $\left(H_1^1\right)$;

$$R_.^1(.)\geq 0.$$

We denote by $\lambda_1^1(q_m)$ the Lagrange multiplier of the constraint $R_1^1(q_m)\geq 0$, by $\lambda_2^1(q_m,P_1,P_2)$ the Lagrange multiplier of the constraint $R_2^1(q_m,P_1,P_2)\geq 0$, and by $\lambda_3^1(q_m,P_1,P_2,v)$ the Lagrange multiplier of the constraint $R_3^1(q_m,P_1,P_2,v)\geq 0$. Similarly λ_H^1 corresponds to the constraint $\left(IC_H^1\right)$, λ_L^1 to the constraint $\left(IC_L^1\right)$, λ_e^1 to the constraint $\left(IC_e^1\right)$, and $\lambda_{H_1^1}$ to the constraint $\left(H_1^1\right)$.

Assume first that the optimal contract entails $R_2^1(1,\varphi,1)>0$ and $R_2^1(0,1-\varphi,0)>0$. This implies that $\lambda_2^1(1,\varphi,1)=0$ and $\lambda_2^1(0,1-\varphi,0)=0$.

FOCs give:

$$\frac{\partial \mathcal{L}}{\partial R_2^1\left(1,\varphi,1\right)}=0 \Leftrightarrow$$

$$\lambda_{H_1^1}=\frac{\varphi}{\frac{\partial U}{\partial R_2^1(1,\varphi,1)}}-2\varphi\lambda_H^1+2\left(1-\varphi\right)\lambda_L^1+\left(1-\varphi\right)\lambda_e^1 \tag{1}$$

$$\frac{\partial \mathcal{L}}{\partial R_2^1\left(0,1-\varphi,0\right)}=0 \Leftrightarrow$$

$$\lambda_e^1=\frac{\varphi}{2\varphi-1}K-2\left(\lambda_H^1+\lambda_L^1\right), \tag{2}$$

where $K=\frac{1}{\frac{\partial U}{\partial R_2^1(1,\varphi,1)}}+\frac{1}{\frac{\partial U}{\partial R_2^1(0,1-\varphi,0)}}$.

Use equation (1) into (2) to obtain:

$$\lambda_{H_1^1}=\varphi M-2\lambda_H^1, \tag{3}$$

where $M=\frac{1}{\frac{\partial U}{\partial R_2^1(1,\varphi,1)}}+\frac{1-\varphi}{2\varphi-1}K$.

Plug (3) into $\frac{\partial \mathcal{L}}{\partial R_1^1(1)}=0$ to find that $\lambda_1^1\left(1\right)=\frac{1}{2}-\frac{\partial U}{\partial R_1^1(1)}\times\frac{\varphi}{2}\times\left[\frac{1}{\frac{\partial U}{\partial R_2^1(1,\varphi,1)}}-\frac{1}{\frac{\partial U}{\partial R_2^1(0,1-\varphi,0)}}\right]$. If $\frac{\partial U}{\partial R_2^1(1,\varphi,1)}=\frac{\partial U}{\partial R_2^1(0,1-\varphi,0)}$ (we show in the proof of proposition 2 that this is true at the optimum), $\lambda_1^1\left(1\right)>0$ and $R_1^1\left(1\right)=0$. Similarly, we can show that $\lambda_1^1\left(0\right)>0$, $\lambda_2^1\left(1,\varphi,\varphi\right)>0$, $\lambda_2^1\left(0,1-\varphi,1-\varphi\right)>0$, $\lambda_2^1\left(1,\frac{1}{2},\frac{1}{2}\right)>0$, $\lambda_2^1\left(0,\frac{1}{2},\frac{1}{2}\right)>0$. This implies that $R_1^1\left(0\right)=R_1^1\left(1\right)=R_2^1\left(1,\varphi,\varphi\right)=R_2^1\left(0,1-\varphi,1-\varphi\right)=R_2^1\left(1,\frac{1}{2},\frac{1}{2}\right)=R_2^1\left(0,\frac{1}{2},\frac{1}{2}\right)=0$. The intuition for these results is that it is counterproductive to pay the manager according to his trading decision only or according to the state of the world, when the latter does not reveal additional information.

Next, we have:

$$\frac{\partial \mathcal{L}}{\partial R_2^1\left(1,\varphi,0\right)}=0 \Leftrightarrow$$

$$\lambda_2^1\left(1,\varphi,0\right)=\frac{1}{8}\left(1-\varphi\right)-\frac{\partial U}{\partial R_2^1\left(1,\varphi,0\right)}\times\frac{\varphi}{8}\times\left(M-\frac{K\varphi}{2\varphi-1}\right). \tag{4}$$

See that $M-\frac{K\varphi}{2\varphi-1}\leq 0$. We thus have $\lambda_2^1(1,\varphi,0)>0$, and $R_2^1(1,\varphi,0)=0$. Using the same approach, it follows that $R_2^1(0,1-\varphi,1)=R_2^1\left(1,\frac{1}{2},0\right)=R_2^1\left(0,\frac{1}{2},1\right)=R_3^1(0,1-\varphi,1,1)=R_3^1\left(1,\frac{1}{2},0,0\right)=R_3^1(1,\varphi,0,0)=R_3^1\left(0,\frac{1}{2},1,1\right)=R_3^1(0,1-\varphi,1-\varphi,1)=R_3^1\left(1,\frac{1}{2},\frac{1}{2},0\right)=R_3^1(1,\varphi,\varphi,0)=R_3^1\left(0,\frac{1}{2},\frac{1}{2},1\right)=0$.

The intuition for these results is that, for incentives reasons, the fund manager is not rewarded when his trading decision is contradicted by the interim price or the final cash-flow.

Given these null transfers, $\left(H_1^1\right)$ can be written as:

$$\left(H_1^1\right):Y\geq X,$$

where $X=\sum_{P_1\in\left\{1-\varphi,\frac{1}{2}\right\}}U\left[R_2^1(0,P_1,0)\right]+\sum_{P_1\in\left\{1-\varphi,\frac{1}{2}\right\}}\sum_{P_2\in\{0,P_1\}}U\left[R_3^1(0,P_1,P_2,0)\right]$, and $Y=\sum_{P_1\in\left\{\frac{1}{2},\varphi\right\}}U\left[R_2^1(1,P_1,1)\right]+\sum_{P_1\in\left\{\varphi,\frac{1}{2}\right\}}\sum_{P_2\in\{P_1,1\}}U\left[R_3^1(1,P_1,P_2,1)\right]$.

Similarly, the incentive constraints can be rewritten:

$$\left(IC_H^1\right):\frac{\varphi}{4}Y\geq\frac{1-\varphi}{4}X,$$

$$\left(IC_L^1\right):\frac{\varphi}{4}X\geq\frac{1-\varphi}{4}Y,$$

$$\left(IC_e^1\right):\frac{1}{2}\frac{\varphi}{4}Y+\frac{1}{2}\frac{\varphi}{4}X-c\geq\frac{1}{8}Y\Leftrightarrow\frac{\varphi}{4}X\geq 2c+\frac{1-\varphi}{4}Y.$$

It is now straightforward to see that $\left(IC_H^1\right)$ is not binding because of $\left(H_1^1\right)$, and $\left(IC_L^1\right)$ because of $\left(IC_e^1\right)$. $\lambda_H^1=\lambda_L^1=0$. Conditions (2) and (3) yield $\lambda_{H_1^1}>0$ and $\lambda_e^1>0$: $\left(H_1^1\right)$ and $\left(IC_e^1\right)$ are binding. It follows that $X=Y$, and $\frac{\varphi}{8}Y=\frac{\varphi c}{2\varphi-1}$. Note that $\frac{\varphi}{8}Y=E_e\left(U\left[R_2^1\left(q_1^m=1,P_1,P_2=1\right)\right]+U\left[R_3^1\left(q_1^m=1,P_1,P_2,v=1\right)\right]\right)=E_e\left(U\left[R_2^1\left(q_1^m=0,P_1,P_2=0\right)\right]+U\left[R_3^1\left(q_1^m=0,P_1,P_2,v=0\right)\right]\right)$.

To complete the proof, one can check that , if one assumes initially that the optimal contract entails $R_2^1(1,P_1,1)>0$ or $R_3^1(1,P_1,P_2,1)>0$, and $R_2^1(0,P_1,0)>0$ or $R_3^1(0,P_1,P_2,0)>0$, for all admissible price paths (P_1,P_2), one obtains the same characterization for the optimal contract.

At the opposite, starting from $R_2^1(1,P_1,0)>0$ or $R_3^1(1,P_1,P_2,0)>0$, and $R_2^1(0,P_1,1)>0$ or

$R_3^1(0, P_1, P_2, 1) > 0$, for all admissible price paths (P_1, P_2), leads to a contradiction.

Assume now that $\varphi > \overline{\beta}$. The program is very similar and is written:

$$\min_{R^1} \Pr(s_1 = H|e) \begin{bmatrix} R_1^1(1) + \frac{1}{4}\varphi \left[R_2^1\left(1, \frac{1}{2}, 1\right) + 2R_3^1(1, \varphi, \varphi, 1) + \sum_{P_2 \in \left\{\frac{1}{2}, 1\right\}} R_3^1\left(1, \frac{1}{2}, P_2, 1\right)\right] \\ +\frac{1}{4}\left[2R_2^1(1, \varphi, \varphi) + R_2^1\left(1, \frac{1}{2}, \frac{1}{2}\right)\right] \\ +\frac{1}{4}(1-\varphi)\left[R_2^1\left(1, \frac{1}{2}, 0\right) + 2R_3^1(1, \varphi, \varphi, 0) + \sum_{P_2 \in \{0, P_1\}} R_3^1\left(1, \frac{1}{2}, P_2, 0\right)\right] \end{bmatrix}$$

$$+\Pr(s_1 = L|e) \begin{bmatrix} R_1^1(0) + \frac{1}{4}\varphi \left[R_2^1\left(0, \frac{1}{2}, 0\right) + 2R_3^1(0, 1-\varphi, 1-\varphi, 0) + \sum_{P_2 \in \left\{0, \frac{1}{2}\right\}} R_3^1\left(0, \frac{1}{2}, P_2, 0\right)\right] \\ +\frac{1}{4}\left[2R_2^1(0, 1-\varphi, 1-\varphi) + R_2^1\left(0, \frac{1}{2}, \frac{1}{2}\right)\right] \\ +\frac{1}{4}(1-\varphi)\left[R_2^1\left(0, \frac{1}{2}, 1\right) + 2R_3^1(0, 1-\varphi, 1-\varphi, 1) + \sum_{P_2 \in \{P_1, 1\}} R_3^1\left(0, \frac{1}{2}, P_2, 1\right)\right] \end{bmatrix},$$

subject to:

$$\left(IC_H^1\right)\ E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m = 1\right)\right)|s_1 = H\right) \geq \frac{1}{4}\varphi \begin{pmatrix} U\left[R_2^1\left(0, \frac{1}{2}, 1\right)\right] + 2U\left[R_3^1(0, 1-\varphi, 1-\varphi, 1)\right] \\ +\sum_{P_2 \in \{P_1, 1\}} U\left[R_3^1\left(0, \frac{1}{2}, P_2, 1\right)\right] \end{pmatrix}$$
$$+\frac{1}{4}\left(2U\left[R_2^1(0, 1-\varphi, 1-\varphi)\right] + U\left[R_2^1\left(0, \frac{1}{2}, \frac{1}{2}\right)\right]\right) + U\left[R_1^1(0)\right]$$
$$+\frac{1}{4}(1-\varphi)\left(U\left[R_2^1\left(0, \frac{1}{2}, 0\right)\right] + 2U\left[R_3^1(0, 1-\varphi, 1-\varphi, 0)\right] + \sum_{P_2 \in \{0, P_1\}} U\left[R_3^1\left(0, \frac{1}{2}, P_2, 0\right)\right]\right),$$

$$\left(IC_L^1\right)\ E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m = 0\right)\right)|s_1 = L\right) \geq +\frac{1}{4}\varphi \begin{pmatrix} U\left[R_2^1\left(1, \frac{1}{2}, 0\right)\right] + 2U\left[R_3^1(1, \varphi, \varphi, 0)\right] \\ +\sum_{P_2 \in \{0, P_1\}} U\left[R_3^1\left(1, \frac{1}{2}, P_2, 0\right)\right] \end{pmatrix}$$
$$U\left[R_1^1(1)\right] + \frac{1}{4}\left[2U\left[R_2^1(1, \varphi, \varphi)\right] + U\left[R_2^1\left(1, \frac{1}{2}, \frac{1}{2}\right)\right]\right]$$
$$+\frac{1}{4}(1-\varphi)\left(U\left[R_2^1\left(1, \frac{1}{2}, 1\right)\right] + 2U\left[R_3^1(1, \varphi, \varphi, 1)\right] + \sum_{P_2 \in \{P_1, 1\}} U\left[R_3^1\left(1, \frac{1}{2}, P_2, 1\right)\right]\right),$$

$$
\begin{aligned}
\left(H_1^1\right)\ U\left[R_1^1(1)\right] + \frac{1}{8}\left(\begin{array}{c} \sum_{P_2\in\{0,1\}} U\left[R_2^1\left(1,\tfrac{1}{2},P_2\right)\right] + 2\left(U\left[R_3^1(1,\varphi,\varphi,1)\right] + U\left[R_3^1(1,\varphi,\varphi,0)\right]\right) \\ +\sum_{P_2\in\{P_1,v\}}\sum_{v\in\{0,1\}} U\left[R_3^1\left(1,\tfrac{1}{2},P_2,v\right)\right] \end{array}\right) \\
+\frac{1}{4}\left(2U\left[R_2^1(1,\varphi,\varphi)\right] + U\left[R_2^1\left(1,\frac{1}{2},\frac{1}{2}\right)\right]\right) \geq \\
U\left[R_1^1(0)\right] + \frac{1}{8}\left(\begin{array}{c} \sum_{P_2\in\{0,1\}} U\left[R_2^1\left(0,\tfrac{1}{2},P_2\right)\right] + 2\left(U\left[R_3^1(0,1-\varphi,1-\varphi,0)\right] + U\left[R_3^1(0,1-\varphi,1-\varphi,1)\right]\right) \\ +\sum_{P_2\in\{P_1,v\}}\sum_{v\in\{0,1\}} U\left[R_3^1\left(0,\tfrac{1}{2},P_2,v\right)\right] \end{array}\right) \\
+\frac{1}{4}\left(2U\left[R_2^1(0,1-\varphi,1-\varphi)\right] + U\left[R_2^1\left(0,\frac{1}{2},\frac{1}{2}\right)\right]\right)
\end{aligned}
$$

where $E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)|s_1=H\right)$ (resp., $E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=0\right)\right)|s_1=L\right)$) is computed using the probability distribution indicated in the objective function.when $s_1=H$ (resp., $s_1=L$);

$$
\begin{aligned}
\left(IC_e^1\right)\ \Pr\left(s_1=H|e\right)\left[E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)|s_1=H\right)\right] + \Pr\left(s_1=L|e\right)\left[E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=0\right)\right)|s_1=L\right)\right] - c \\
\geq E_{ne}\left[\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)\right],
\end{aligned}
$$

where $E_{ne}\left[\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m=1\right)\right)\right]$ is the left-hand side of $\left(H_1^1\right)$;

$$
R_{\cdot}^1(.) \geq 0.
$$

The only difference with the previous program is that, when $P_1=\varphi$ or $P_1=1-\varphi$, $P_2=P_1$ with probability 1. The resolution of the program is the same as before and yields the same characterization of the optimal contract in terms of expected utility granted to the fund manager. As we show in proposition 2, what will differ is the exact transfers.

Proof of corollary 1

Manager 1's agency rent is equal to:

$$\Pr\left(s_1 = H|e\right)\left[E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m = 1\right)\right)|s_1 = H\right)\right] + \Pr\left(s_1 = L|e\right)\left[E_e\left(\sum_{t=1}^{t=3} U\left(R_t^1\left(q_1^m = 0\right)\right)|s_1 = L\right)\right] - c$$
$$= \frac{1}{2} \times \frac{2\varphi c}{2\varphi - 1} + \frac{1}{2} \times \frac{2\varphi c}{2\varphi - 1} - c$$
$$= \frac{c}{2\varphi - 1}.$$

Proof of proposition 2

When $\varphi \leq \overline{\beta}$, using the proof of Proposition 1, investor 1 has the following program:

$$\begin{aligned}
&\min_{R_\cdot^1} \Pr\left(s_1 = H|e\right)\ \tfrac{1}{4}\varphi \textstyle\sum_{P_1 \in \left\{\frac{1}{2}, \varphi\right\}} \left[R_2^1\left(1, P_1, 1\right) + \sum_{P_2 \in \{P_1, 1\}} R_3^1\left(1, P_1, P_2, 1\right)\right] \\
&+ \Pr\left(s_1 = L|e\right)\ \tfrac{1}{4}\varphi \textstyle\sum_{P_1 \in \left\{1-\varphi, \frac{1}{2}\right\}} \left[R_2^1\left(0, P_1, 0\right) + \sum_{P_2 \in \{0, P_1\}} R_3^1\left(0, P_1, P_2, 0\right)\right]\ , \\
s.t.\quad & \textstyle\sum_{P_1 \in \left\{\frac{1}{2}, \varphi\right\}} U\left[R_2^1\left(1, P_1, 1\right)\right] + \sum_{P_1 \in \left\{\varphi, \frac{1}{2}\right\}} \sum_{P_2 \in \{P_1, 1\}} U\left[R_3^1\left(1, P_1, P_2, 1\right)\right] = \frac{8c}{2\varphi - 1} \\
& \textstyle\sum_{P_1 \in \left\{1-\varphi, \frac{1}{2}\right\}} U\left[R_2^1\left(0, P_1, 0\right)\right] + \sum_{P_1 \in \left\{1-\varphi, \frac{1}{2}\right\}} \sum_{P_2 \in \{0, P_1\}} U\left[R_3^1\left(0, P_1, P_2, 0\right)\right] = \frac{8c}{2\varphi - 1} \\
& R_\cdot^1 \geq 0
\end{aligned}$$

FOCs give that marginal utilities are equal across states. It follows that:

$$R_\cdot^1 = U^{-1}\left(\frac{4c}{3(2\varphi - 1)}\right),$$

and manager 1's expected bonus is:

$$E\left(R_{\varphi \leq \overline{\beta}}^1\right) = \frac{3}{2}\varphi U^{-1}\left(\frac{4c}{3\left(2\varphi - 1\right)}\right).$$

When $\varphi > \overline{\beta}$, investor 1's program is:

$$\begin{aligned}
&\min_{R_\cdot^1} \Pr\left(s_1 = H|e\right)\frac{1}{4}\varphi\left[\ R_2^1\left(1, \tfrac{1}{2}, 1\right) + 2R_3^1\left(1, \varphi, \varphi, 1\right) + \textstyle\sum_{P_2 \in \{P_1, 1\}} R_3^1\left(1, \tfrac{1}{2}, P_2, 1\right)\ \right] \\
&+ \Pr\left(s_1 = L|e\right)\frac{1}{4}\varphi\left[\ R_2^1\left(0, \tfrac{1}{2}, 0\right) + 2R_3^1\left(0, 1-\varphi, 1-\varphi, 0\right) + \textstyle\sum_{P_2 \in \{0, P_1\}} R_3^1\left(0, \tfrac{1}{2}, P_2, 0\right)\ \right], \\
s.t.\quad & U\left[R_2^1\left(1, \tfrac{1}{2}, 1\right)\right] + 2U\left[R_3^1\left(1, \varphi, \varphi, 1\right)\right] + \textstyle\sum_{P_2 \in \{P_1, 1\}} U\left[R_3^1\left(1, \tfrac{1}{2}, P_2, 1\right)\right] = \frac{8c}{2\varphi - 1} \\
& U\left[R_2^1\left(0, \tfrac{1}{2}, 0\right)\right] + 2U\left[R_3^1\left(0, 1-\varphi, 1-\varphi, 0\right)\right] + \textstyle\sum_{P_2 \in \{0, P_1\}} U\left[R_3^1\left(0, \tfrac{1}{2}, P_2, 0\right)\right] = \frac{8c}{2\varphi - 1} \\
& R_\cdot^1 \geq 0
\end{aligned}$$

This yields:

$$R^1_{\cdot} = U^{-1}\left(\frac{8c}{5(2\varphi-1)}\right),$$

and manager 1's expected bonus is:

$$E\left(R^1_{\varphi>\overline{\beta}}\right) = \frac{5}{4}\varphi U^{-1}\left(\frac{8c}{5\left(2\varphi-1\right)}\right).$$

Next, see that:

$$\begin{aligned} & E\left(R^1_{\varphi\leq\overline{\beta}}\right) < E\left(R^1_{\varphi>\overline{\beta}}\right) \\ \Leftrightarrow \quad & 6U^{-1}\left(\tfrac{4c}{3(2\varphi-1)}\right) < 5U^{-1}\left(\tfrac{8c}{5(2\varphi-1)}\right) \end{aligned}$$

U is increasing and strictly concave, which implies that U^{-1} is increasing and strictly convex. Therefore:

$$\begin{aligned} & \left(\tfrac{8c}{5(2\varphi-1)} - \tfrac{4c}{3(2\varphi-1)}\right)U^{-1}\left(\tfrac{4c}{3(2\varphi-1)}\right) < \tfrac{4c}{3(2\varphi-1)}\left(U^{-1}\left(\tfrac{8c}{5(2\varphi-1)}\right) - U^{-1}\left(\tfrac{4c}{3(2\varphi-1)}\right)\right) \\ \Leftrightarrow \quad & U^{-1}\left(\tfrac{4c}{3(2\varphi-1)}\right) < 5\left(U^{-1}\left(\tfrac{8c}{5(2\varphi-1)}\right) - U^{-1}\left(\tfrac{4c}{3(2\varphi-1)}\right)\right), \end{aligned}$$

which yields $E\left(R^1_{\varphi\leq\overline{\beta}}\right) < E\left(R^1_{\varphi>\overline{\beta}}\right)$.

Last, let us see that $E\left(R^1_{\varphi\leq\overline{\beta}}\right)$ decreases with φ.

$$\begin{aligned} & \tfrac{\partial E\left(R^1_{\varphi\leq\overline{\beta}}\right)}{\partial\varphi} < 0 \\ \Leftrightarrow \quad & U^{-1}\left(\tfrac{4c}{3(2\varphi-1)}\right) < \tfrac{8\varphi c}{3(2\varphi-1)^2}(U^{-1})'\left(\tfrac{4c}{3(2\varphi-1)}\right). \end{aligned} \tag{5}$$

Again, use the convexity of U^{-1} to see that:

$$U^{-1}\left(\frac{4c}{3\left(2\varphi-1\right)}\right) < \frac{4\varphi c}{3(2\varphi-1)}(U^{-1})'\left(\frac{4c}{3\left(2\varphi-1\right)}\right) \tag{6}$$

Multiply the (RHS) of (6) by $\frac{2\varphi}{2\varphi-1}$ to show that (5) holds.

Proof of corollary 2

To prove this corollary, we analyze investor 1's participation constraint. Recall that, with symmetric information, long-term information is acquired if and only if $\varphi > \varphi^{FB} = \frac{1}{2} + 4E(R^1_{FB})$.

Recall that the expected trading profit is $\frac{2\varphi-1}{8}$. φ^* solves:

$$\varphi^* = \frac{1}{2} + 4E(R^1_{\varphi \leq \overline{\beta}}).$$

And φ^{**} solves:

$$\varphi^{**} = \frac{1}{2} + 4E(R^1_{\varphi > \overline{\beta}}).$$

Use the convexity of U^{-1} to see that:

$$U^{-1}\left(\frac{4c}{3\,(2\varphi-1)}\right) > \frac{4}{2\varphi-1}U^{-1}(\frac{c}{3}) \tag{7}$$

The (RHS) of (7) is greater than $\frac{2}{\varphi}U^{-1}(\frac{c}{3})$, which implies that: $E(R^1_{\varphi \leq \overline{\beta}}) > E(R^1_{FB})$ and $\varphi^* > \varphi^{FB}$.

Last, because $E(R^1_{\varphi \leq \overline{\beta}}) < E(R^1_{\varphi > \overline{\beta}})$, it follows immediately that $\varphi^{**} > \varphi^*$.

Proof of proposition 3

Use the proof of proposition 1 to see that all transfers are null when the portfolio performance is null or negative. Use the proof of proposition 2 to see that all positive bonuses are equal to $U^{-1}\left(\frac{4c}{3(2\varphi-1)}\right)$ when $\varphi \leq \overline{\beta}$ and are equal to $U^{-1}\left(\frac{8c}{5(2\varphi-1)}\right)$ when $\varphi > \overline{\beta}$.

Proof of proposition 4

When $\varphi \leq \overline{\beta}$, the expected long term bonus is equal to: $\varphi U^{-1}\left(\frac{4c}{3(2\varphi-1)}\right)$. The ratio of long term expected bonus over total expected bonus is thus $\frac{2}{3}$. Proceed in the same way to show that when $\varphi > \overline{\beta}$, the ratio of long term expected bonus over total expected bonus is $\frac{4}{5}$, which completes the proof.

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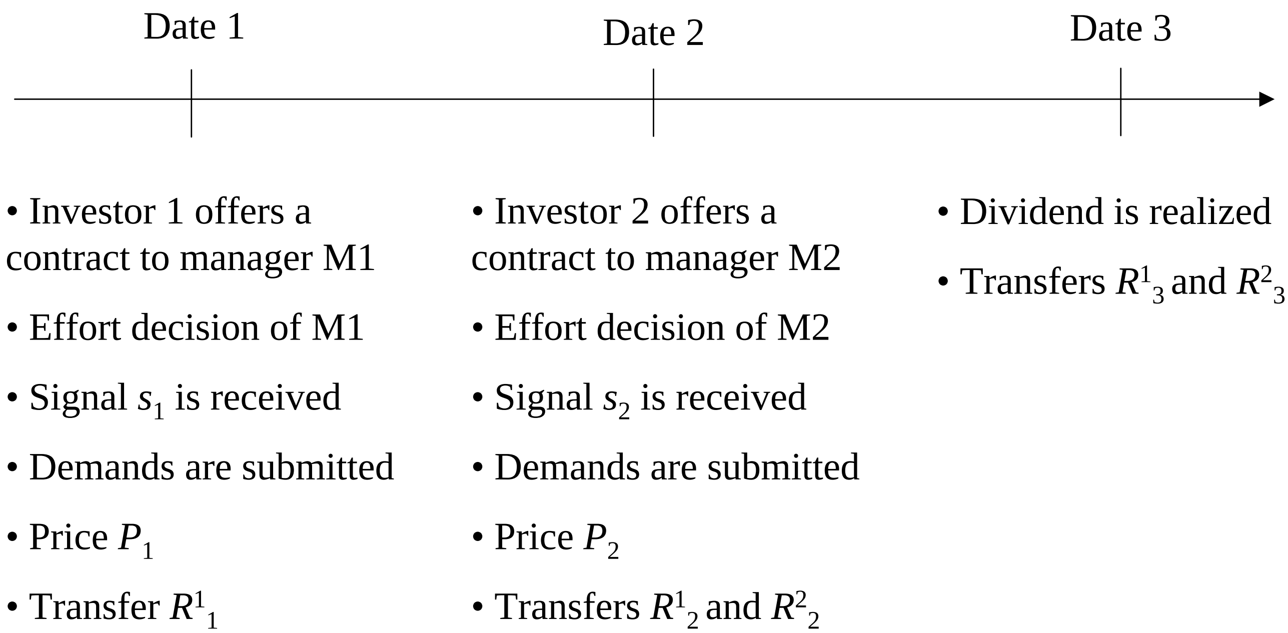

Figure 1: Timing of the model

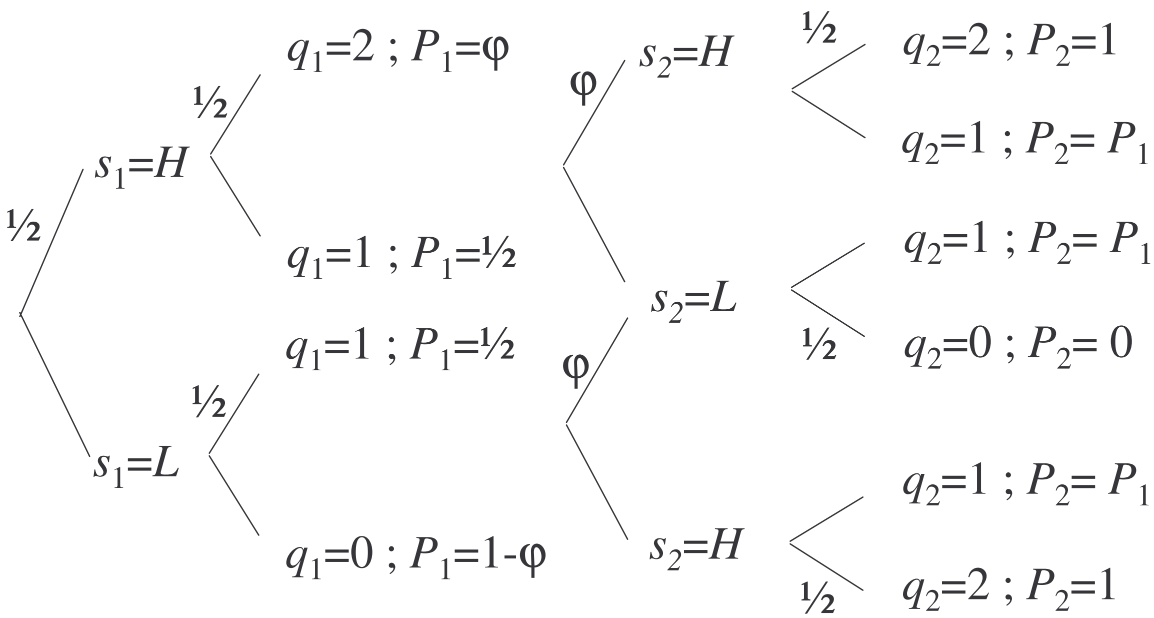

Figure 2: Prices when managers exert effort and buy after good news only

The distribution of managers' signals is computed as follows. When Manager 1 exerts effort, $\Pr(s_1 = H) = \frac{1}{2}\varphi + \frac{1}{2}(1-\varphi) = \frac{1}{2}$. Similarly, $\Pr(s_2 = H | s_1 = H) = \varphi$. Notice that, when total demand q_t=1, market makers learn nothing and P_t=P_{t-1}. When total demand is q_t=2 (respectively, q_t=0), the price moves upward (respectively, downward) according to the quality of the information being revealed.

Figure3: Short-termism due to delegated portfolio management

This figure illustrates how short-termism arises in our model: the grey area is the region where long-term information is not acquired because of moral hazard. φ represents the precision of the portfolio manager's information. The expected trading profit is the increasing blue line. Manager's expected compensation is represented by a dotted red curve. The difference between expected compensation and the cost c of gathering information is due to informational rents. When φ is smaller than $\overline{\beta}$, the interim price is very efficient due to informed trading and the incentive cost decreases. When φ is larger, there is less interim informed trading. If the manager is not too risk averse (see Panel A), the expected compensation curve is not altered. Otherwise, the cost of incentives increases (see Panel B), shifting upward the expected compensation curve. Short-termism increases with risk aversion (see Panels C and D).