Executive Compensation and Short-termist Behavior in Speculative Markets*

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Abstract

We present a multiperiod agency model of stock based executive compensation in a speculative stock market, where investors are overconfident and stock prices may deviate from underlying fundamentals and include a speculative option component. This component arises from the option to sell the stock in the future to potentially overoptimistic investors. We show that optimal compensation contracts may emphasize short-term stock performance, at the expense of long run fundamental value, as an incentive to induce managers to pursue actions which increase the speculative component in the stock price. Our model provides a different perspective for the recent corporate crisis than the increasingly popular 'rent extraction view' of executive compensation.

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1 Introduction

The classical view of executive compensation is that it is an optimal form of compensation designed to solve an agency problem between the firm's managers and their shareholders. As the seminal work of Mirrlees (1975) and Holmstrom (1979) establishes, compensation contracts based on the firm's performance motivate firm managers to work in the interest of shareholders. More recently, Holmstrom and Tirole (1993) have extended the classic moral hazard framework to settings where the firm's stock is traded in a secondary market and where the manager's compensation can be tied to the stock price. A key assumption in their analysis is that stock markets are efficient in the sense that stock prices are an unbiased estimate of the firm's fundamental value. As a result, stock prices provide useful information to shareholders about managerial effort choice, and therefore affect managerial compensation.

In this paper we depart from Holmstrom and Tirole (1993) by introducing a 'speculative stock market' where stock prices reflect not only the fundamental value of the firm but also a short-term speculative component and we analyze the implications for executive compensation. There is growing evidence that stock prices can deviate from fundamental values for prolonged periods of time.[1] While many economists believe in the long run efficiency of stock markets they also recognize that US stock markets have displayed an important speculative component during the period between 1998 to 2000.[2] In addition, several recent studies have shown that it is difficult to reconcile the stock price levels and volatility of many internet and high-tech firms during this period with standard discounted cash-flow valuations.[3] In some highly publicized cases the market value of a parent company was even less than the value of its holdings in an "internet" subsidiary. The trading volume for these stocks was also much higher than that for more traditional companies, a likely indicator of differences of opinion among investors regarding the fundamental values of these stocks.[4]

Many questions arise concerning the use of stocks in CEO compensation contracts when stock prices may not always reflect the fundamental value of the firm. For example, what

[1] See Shleifer (2000) and Shiller (2000) for supporting arguments and Fama (1998) for a contrarian view.
[2] *e.g.* Malkiel (2003)
[3] See Lamont and Thaler (2003), Ofek and Richardson (2003), and Cochrane (2002).
[4] An extreme example is the trading volume in Palm stock, which turned over once every day according to Lamont and Thaler (2003, Table 8).

kind of incentive would stock compensation provide to firm managers in such an environment? Would investors be willing to use stocks for compensating managers if they knew that stock prices could deviate substantially from fundamental value? More generally, what is "shareholder value" in such a speculative market? Our goal in this paper is to set up a tractable theoretical model to address these questions and to provide an analysis of optimal CEO compensation in speculative markets.

We consider an optimal contracting problem in a two-period principal-agent model similar to Holmstrom and Tirole (1993). We let a risk-averse CEO choose some costly hidden actions, which affect both the long-run fundamental value of the firm (in period 2) and its short-run stock valuation (in period 1). For optimal risk diversification reasons, when the stock price is an unbiased estimate of the fundamental value of the firm, the optimal (linear) CEO compensation scheme has both a short-run and a long-run stock participation component.

Our fundamental departure from Holmstrom and Tirole (1993) is the introduction of a 'speculative stock market'. Specifically, we build on the model of equilibrium stock-price dynamics in the presence of 'overconfident' investors by Scheinkman and Xiong (2003).[5] In this model, overconfidence provides a source of heterogeneous beliefs among investors, which lead them to speculate against each other. The holder of a share then has not only a claim to future dividends but also an option to sell the stock to a more optimistic investor in the future. Stock prices in this model have two components: a long-run fundamental and a short-term speculative component. Investors are willing to pay more than what they believe to be the stock's long-run fundamental value because they think they may be able to sell their shares in the short-term to other investors with more optimistic beliefs.[6]

Another departure from Holmstrom and Tirole (1993) is that the manager faces a multi-task problem similar to Holmstrom and Milgrom (1992). That is, the CEO can divide his time between increasing the long-term value of the firm and encouraging speculation in the

[5] Overconfidence is a frequently observed behavioral bias in psychological studies. See Barber and Odean (2001), and Daniel, Hirshleifer and Teoh (2002) for reviews of the related psychological studies and the applications of overconfidence in economics and finance.

[6] In a thought-provoking account of the internet bubble, Michael Lewis (2002) has given a vivid description of the thought process of many investors, when he explained the reasoning behind his purchase of the internet company stock Exodus Communications at the end of 1999: "I figured that even if Exodus Communications didn't wind up being a big success, enough people would believe in the thing to drive the stock price even higher and allow me to get out with a quick profit." [Michael Lewis, 2002].

stock in the short-term by pursuing projects over which investors are likely to have diverging beliefs. In times of great investor overconfidence, the optimal incentive contract is designed to partially or completely induce the CEO to pursue the strategy that tends to exacerbate investors' differences of opinion and to bring about a higher speculative option value. Importantly, both initial shareholders and the CEO can gain from this strategy since it may increase the stock price in the short run.[7]

Our model provides a new perspective on the question of the efficiency of stock compensation following the recent collapse of several major publicly traded companies such as Enron and Worldcom.[8] An increasingly influential view holds that the frequently observed CEO compensation contracts that allow for the short term 'exit' of CEOs are a form of managerial abuse brought about by a lack of adequate board supervision (see Bebchuk, Fried and Walker 2002).[9] The theory outlined in this paper provides another reason why short term 'exit' of CEOs was facilitated. This may have been an optimal form of compensation designed to induce CEOs to focus on speculative ventures during an unusually speculative phase of stock markets.[10] Indeed, we show that when markets are highly speculative the optimal managerial compensation is tilted towards short-term performance at the cost of neglecting long run value. An implication of our analysis is that failure to maximize long-run firm value is not necessarily a symptom of weak corporate governance. Similarly, policies aimed at strengthening board supervision alone would not necessarily result in different or more long-term oriented CEO compensation.

Rent-seeking behavior by managers is always present, but the existing rent seeking theories fail to explain why rent-seeking behavior would have been particularly successful during the bubble period. In contrast, our model suggests that short-termist behavior is likely to be en-

[7] In some cases these initial shareholders are venture capitalists, who typically structure the manager's contracts in new firms.

[8] The Financial Times has conducted a survey of the 25 largest financially distressed firms since January 2001 and found that, although hundreds of billions of investor wealth together with 100,000 jobs disappeared, top executives and directors in these firms walked away with a total of $3.3 billion by selling their stock holdings early. On the other hand, investors had lost hundreds of billions of dollars (see Financial Times, July 31, 2002).

[9] Murphy (2002) proposes instead that compensation committees have under-estimated the cost of issuing stocks and options to managers.

[10] "In the bubble, the carrots (stock options) became managerial heroin, encouraging a focus on short-term prices with destructive long-term consequences. ... It also encourages behavior that actually reduced the value of some firms to their shareholders - such as making an acquisition or spending a fortune on an internet venture to satisfy the whims of an irrational market." Michael Jensen, an early proponent of increasing performance based compensation for CEOs, as quoted in the Economist, November 16, 2002.

couraged in firms in new industries, where it is usually more difficult to evaluate fundamentals and therefore easier for disagreement among potential investors to arise.

The paper proceeds as follows. In Section 2, we discuss the related literature on managerial short-termism. Section 3 describes the model. Section 4 derives the optimal CEO compensation contract under the classical assumption that stock markets are efficient. In Section 5, we introduce overconfident investors and characterize the optimal contract in the presence of a speculative market. Section 6 discusses comparative statics. In Section 7, we provide some discussion and empirical implications.

2 The related literature

Short-termist behavior by managers has been highlighted before (most notably, Stein 1988, 1989, Shleifer and Vishny 1990, and Von Thadden 1995). Stein (1988) shows that takeover threat can cause managerial myopia in the sense that managers will be forced to put too much emphasis on short-term earnings in order to avoid their firm shares being under-valued and subsequent takeovers. Stein (1989) and Von Thadden (1995) demonstrate that imperfection in investors' information set on managerial effort choices can lead a firm to undertake myopic investment through a "signal jamming" mechanism, and this short-term bias cannot be easily fixed by renegotiation-proof long-term contracts without active investor monitoring. Shleifer and Vishny (1990) stress that the failure of arbitrage trading in making accurate prices of long-term assets can lead to inefficiency in managerial contracting. In summary, managerial short-termism in these models is not induced by some optimal incentive scheme, but rather due to information or other forms of imperfection, and it arises against the wishes of shareholders. To the contrary, the managerial short-termist analyzed in our paper is consistent with speculative motive of incumbent shareholders, and therefore would not be eliminated even with active shareholder intervention.

More closely related to our paper is Froot, Perold and Stein (1992) who provide a discussion of the potential link between the short-term horizon of shareholder and short-term managerial behavior. They precisely point out that the effective horizon of institutional investors, as measured by the frequency of their share turnover, is about one year, much shorter than the necessary period for them to exert long-term discipline on firm managers. However, their paper does not provide a formal model or analysis of optimal incentive compensation in an environment in which controlling shareholders have a short-term objective.

Another related literature deals with the incentive effects of early 'exit' by managers or large shareholders (for example Maug 1998, Kahn and Winton 1998, Bolton and von Thadden 1998, and Aghion, Bolton and Tirole 2000). However, this literature assumes that stock markets are efficient. More recently, Bebchuk and Bar-Gill (2003) have analyzed the cost of permitting better informed managers to sell shares early, but they do not study the optimal compensation scheme that would be chosen by shareholders in their framework.

3 The model

We consider a publicly traded firm run by a risk-averse CEO. There are three dates: $t = 0, 1, 2$. The firm is liquidated at $t = 2$. At $t = 0$, the manager can divide his effort between two projects: a project with a higher long-term expected return and a project with an inferior long-run expected return but which is more likely to be overvalued by overconfident investors in the secondary market[11]. For simplicity, we set the interest rate to zero. We also assume that shareholders and potential investors are risk-neutral while the CEO is risk-averse. [12]

The firm's long-term value at $t = 2$, thus, has three additive components:

$$e = u + v + \epsilon,$$

where,

- u represents the realized value of the first project. It is a normally distributed random variable with mean $h\mu$ and variance σ^2 (or precision $\tau = 1/\sigma^2$). Here $\mu \geq 0$ denotes the CEO's hidden "effort", and $h > 0$ is a parameter measuring the expected return of effort. The variance σ^2 is outside the manager's control.

- v is the terminal value of the inferior project, which we refer to as a "castle-in-the-air" venture. It is also a normally distributed random variable. To be able to define a simple

[11] Examples of this type of project are the internet ventures cited in the quote in footnote 10.

[12] The standard justification for shareholders' risk-neutrality is that they can diversify firm specific risk, while the CEO cannot.

benchmark under an efficient stock market with no speculative trading, we assume that the unit return on this project, which we denote by z, has a fixed mean which we normalize to 0. The unit variance of this project is l^2.

This project can be scaled up by the CEO by raising the level of effort ω devoted to the project. For a given choice of ω the total variance of the project is then $\omega^2 l^2$. In other words, this is a constant return to scale project with an inferior long-term mean return. The attraction of this project, however, is that it might become over-valued by some investors in a speculative market. We will show that in an efficient stock market, optimal compensation design would lead the CEO to spend no effort on this project. However this will not be the case in a speculative stock market.

- ϵ is a pure noise term; it is a normally distributed random variable with mean 0 and variance σ_ϵ^2 (or precision $\tau_\epsilon = 1/\sigma_\epsilon^2$).

If we let the random variable W denote financial stake of the CEO in the firm then the CEO's payoff is represented by the usual additively separable utility function:

$$\mathrm{E}_0 u(W) - \psi(\mu, \omega)$$

where $\psi(\mu, \omega)$ is the CEO's hidden cost of effort function, which we assume to take the simple quadratic form:

$$\psi(\mu, \omega) = \frac{1}{2}(\mu + \omega)^2.$$

We make the additional simplifying assumption that the CEO's attitudes towards risk can be summarized by the following mean-variance preferences.

$$\mathrm{E}_0 u(W) = \mathrm{E}_0(W) - \frac{\gamma}{2} Var_0(W),$$

where $\gamma > 0$ measures the CEO's aversion to risk.

Intuitively, one can think of μ and ω as time spent on the two separate projects. Under this formulation the two activities are substitutes and there are diminishing returns to spending more time on each task.

At $t = 1$, two signals are publicly observed by all participants. Signal s provides information about u, and signal θ information about v. We assume that,

$$\begin{aligned} s &= u + \epsilon_s, \\ \theta &= z + \epsilon_\theta, \end{aligned}$$

where ϵ_s and ϵ_θ are again normally distributed random variables with mean 0 and respective variances σ_s^2 and σ_θ^2, (or precisions $\tau_s = 1/\sigma_s^2$ and $\tau_\theta = 1/\sigma_\theta^2$). To simplify our notation, we write

$$\sigma_\theta^2 = \eta\sigma_z^2 = \eta l^2$$

where, η is a constant measuring the informativeness of signal θ. The two signals allow participants to revise their beliefs about the long-term value of the firm.

After observing the signals investors can trade the firm's stocks, in a competitive market, at $t = 1$. The determination of investors' beliefs and the resulting equilibrium price in the secondary market p_1 are a central part of our analysis. We normalize the initial number of shares held by investors to one.

The central problem for shareholders at $t = 0$ is to design a CEO compensation package to motivate the CEO to allocate her time optimally between the two tasks and between 'work' and 'leisure', without exposing her to too much risk. As is standard in the theoretical literature on executive compensation we will only consider linear compensation contracts[13]. Our compensation contracts specify both a short-term and a long-term equity stake for the manager and take the form:

$$W = ap_1 + be + c, \tag{1}$$

where:

- p_1 represents the firm's stock value at $t = 1$,
- a denotes the short-run weighting of the CEO's compensation (the fraction of non-vested CEO shares),

[13] A few recent attempts have been made to explore more general non-linear (option-like) contracts (see e.g. Hemmer et al. 2000, and Huang and Suarez 1997).

- b is the long-run weighting (the fraction of CEO share ownership that is tied up until $t = 2$), and

- c is the non-performance based compensation component.

The initial shareholders'problem is then to choose the contract $\{a, b, c\}$ (through the board of directors, or the compensation committe) to maximize the firm's stock price at $t = 0$, subject to satisfying the manager's participation and incentive constraints. Formally, the initial shareholders' problem is given by[14]:

$$\max_{a,b,c,\mu,\omega} \quad (1-a-b)p_0 - c \quad = \quad (1-a-b)\mathrm{E}_0(p_1) - c$$

subject to

$$\max_{\mu,\omega} \ \mathrm{E}_0(ap_1 + be + c) - \frac{\gamma}{2}Var_0(ap_1 + be + c) - \frac{1}{2}(\mu + \omega)^2 \geq \bar{W},$$

where $\bar{W}$ is the manager's reservation utility[15].

The timing of events is as follows: At $t = 0$, initial shareholders determine the managerial contract $\{a, b, c\}$. Then the manager chooses her actions μ and ω. At $t = 1$, market participants trade stocks based on the realized signals s and θ. At $t = 2$, the firm is liquidated and the final value e is divided among shareholders after deducting the CEO's pay.

[14] In section 7 we also consider a more general objective function for shareholders, which takes account of the fact that they may not be continually present in the market and may be 'buy-and-hold' investors:

$$\max_{\{a,b,c\}} \ (1-a-b)[\lambda E_0[p_1] + (1-\lambda)E_0[e]] - c$$

where, $\lambda \in (0, 1)$ represents the probability that the shareholder will be present in the secondary-market at $t = 1$. The lower is λ the higher is the shareholder's long-term orientation.

[15] Sometimes this formulation is misinterpreted as meaning that shareholders have all the bargaining power (a patently counterfactual assumption) and can force the CEO down to her reservation utility level. But the solution to the dual problem

$$\max_{a,b,c}\{\mathrm{E}_0(W) - \frac{\gamma}{2}Var_0(W) - \frac{1}{2}(\mu + \omega)^2\} \quad \text{subject to} \quad p_0 \geq \overline{p}_0,$$

would be the same up to a constant. In the standard agency problem the bargaining power of the manager determines the level of her total compensation (c), but not the structure of the compensation package (a and b).

4 Optimal executive compensation in an efficient market

To set a benchmark, we begin by solving for the optimal CEO compensation contract under the assumption that there are no overconfident investors. This section mostly builds on and adapts the analysis of Holmstrom and Tirole (1993). In an efficient market, the stock price p_1 incorporates all the information contained in the short-term signals s and θ that investors observe. Since, however, s and θ are noisy signals of u and z, the short-term stock price p_1 cannot be a sufficient statistic for the manager's effort choice μ and ω. Therefore, since the CEO is risk-averse, one should expect her compensation package to have both a short-run and long-run component.

4.1 Informationally efficient stock markets

More formally, if all the market participants are fully rational, equilibrium stock prices at $t = 0$ and $t = 1$ are given by:

$$p_0 = \mathrm{E}_0(p_1) \quad \text{and} \quad p_1 = \mathrm{E}(e - W|s, \theta),$$

where W is the compensation to the manager.

In a rational expectations equilibrium shareholders correctly expect the manager to choose the optimal actions μ^* and ω^* under the CEO compensation contract, and form the following conditional expectations:

$$\begin{aligned} \mathrm{E}(e|s,\theta) &= \mathrm{E}(u|s) + \mathrm{E}(v|\theta) \\ &= h\mu^* + \frac{\tau_s}{\tau + \tau_s}(s - h\mu^*) + \frac{\tau_\theta}{\tau_z + \tau_\theta}\theta\omega^* \qquad (2) \\ &= h\mu^* + \frac{\tau_s}{\tau + \tau_s}(u - h\mu^* + \epsilon_s) + \frac{1}{\eta + 1}\theta\omega^* \qquad (3) \end{aligned}$$

Equation (2) is the standard expression for the conditional expectation given that u, s, v, and θ are normally distributed random variables with respective precisions τ, τ_s, τ_z, and τ_θ (see, e.g. DeGroot 1970). Equation (3) follows immediately upon substitution of $\tau_z/\tau_\theta = \eta$.

The equilibrium stock price at $t = 1$ is defined by the following equation:

$$p_1 = \mathrm{E}(e - W|s, \theta) = \mathrm{E}[e - (ap_1 + be + c)|s, \theta]$$

Or, solving out for p_1,

$$p_1 = \frac{1-b}{1+a}\mathrm{E}(e|s,\theta) - \frac{c}{1+a} \tag{4}$$

where the factors $\left(\frac{1-b}{1+a}\right)$ and $\left(\frac{c}{1+a}\right)$ represent the residual stock value net of the manager's stake.

Substituting this expression for the equilibrium price p_1 into the equation (1) defining the manager's compensation, we obtain:

$$W = \alpha\mathrm{E}(e|s,\theta) + \beta e + \delta,$$

with α, β and δ given by:

$$\alpha = \frac{a}{1+a}(1-b), \quad \beta = b, \quad \delta = \frac{c}{1+a}.$$

Thus, α denotes the percentage ownership in the firm that the manager is allowed to sell in the first period, β the percentage ownership in the firm that the manager must hold until the end, and δ the manager's non-performance based compensation.

In practice, CEO compensation packages typically satisfy $0 \leq \beta < 1$ and $0 < \alpha < 1 - \beta$. That is, CEOs are not allowed to short the stock of their company and C.E.O.s do not hold the entire equity of the firm. Accordingly, we shall restrict attention to contracts such that $\alpha \geq 0$, $\beta \geq 0$ and $\alpha + \beta \leq 1$.

4.2 The Manager's optimization problem

Given a contract $\{\alpha, \beta, \delta\}$, the manager chooses her actions μ and ω to solve

$$\max_{\mu,\omega}\ \mathrm{E}_0\left[\alpha\mathrm{E}(e|s,\theta) + \beta e\right] - \frac{1}{2}(\mu+\omega)^2 - \frac{\gamma}{2}Var_0\left[\alpha\mathrm{E}(e|s,\theta) + \beta e\right].$$

It is immediately apparent from this objective that it is optimal for the manager to set $\omega = 0$ under any contract $\{\alpha, \beta, \delta\}$. This is to be expected. Since spending effort ω on the 'castle-in-the-air' project does not affect the equilibrium stock price in an informationaly efficient market, it never pays to set $\omega > 0$. A higher ω only increases the variance of the manager's payoff and involves a higher effort cost. Thus, in an informationally efficient stock market, the

C.E.O. would not engage in any short-termist behavior[16]. This is obviously also expected by shareholders. So that we can write:

$$\omega^*(\alpha,\beta) = 0.$$

Setting $\omega = 0$ and substituting for the expression for $\mathrm{E}(e|s,\theta)$ in equation (3), the CEO's problem can then be reduced to choosing μ to solve:

$$\max_{\mu} \left(\frac{\tau_s}{\tau+\tau_s}\alpha + \beta\right) h \cdot (\mu - \mu^*) - \frac{1}{2}\mu^2$$

And the first order conditions to this problem fully characterize the CEO's optimal action choice:

$$\mu^*(\alpha,\beta) = h \cdot \left(\frac{\tau_s}{\tau+\tau_s}\alpha + \beta\right). \tag{5}$$

Note that any combination of long-term and short-term stock participation which keeps $\left(\frac{\tau_s}{\tau+\tau_s}\alpha + \beta\right)$ constant would give the same incentive to choose μ. Note also that since the stock price p_1 is built on noisy information about the fundamental value of the firm u, the incentive effect of the short-term stock participation α is dampened to $\frac{\tau_s}{\tau+\tau_s}\alpha$.

Next, substituting for $\omega^*(\alpha,\beta)$ and $\mu^*(\alpha,\beta)$ in (3) we obtain the unconditional expectated firm value at $t = 0$:

$$\mathrm{E}_0[e] = \mathrm{E}_0[\mathrm{E}(e|s,\theta)] = h\mu$$

where μ is the effort choiceof the CEO, as given in equation (5).

In addition, the manager's individual rationality constraint is binding under an optimal contract, so that

$$\mathrm{E}_0[W] - \frac{1}{2}(\mu^*(\alpha,\beta))^2 - \frac{\gamma}{2}Var_0\left[\alpha\mathrm{E}(e|s,\theta) + \beta e\right] = \bar{W}, \tag{6}$$

where:

$$\begin{aligned} Var_0\left[\alpha\mathrm{E}(e|s,\theta) + \beta e\right] &= Var_0\left[\left(\frac{\tau_s}{\tau+\tau_s}\alpha + \beta\right)(u - h\mu^*(\alpha,\beta)) + \frac{\tau_s}{\tau+\tau_s}\alpha\epsilon_s + \beta\epsilon\right] \\ &= \frac{1}{\tau}\left(\frac{\tau_s}{\tau+\tau_s}\alpha + \beta\right)^2 + \frac{\alpha^2\tau_s}{(\tau+\tau_s)^2} + \frac{\beta^2}{\tau_\epsilon}. \end{aligned} \tag{7}$$

[16] This result contrasts with Stein (1989) and Von Thadden (1995) where short-termist behavior can take place in an efficient stock market for 'signal jamming' reasons.

4.3 The shareholder's optimization problem

Combining equations (5), (6), and (7) we can formulate the shareholders' optimal contracting problem as follows:

$$
\begin{aligned}
\max_{\alpha,\beta} \; p_0 &= \max_{\{\alpha,\beta\}} \; \mathrm{E}_0[e - W] \\
&= \max_{\{\alpha,\beta\}} \left\{ h\mu - \bar{W} - \frac{1}{2}\mu^2 - \frac{\gamma}{2}\left[\frac{1}{\tau}\left(\frac{\tau_s}{\tau+\tau_s}\alpha+\beta\right)^2 + \frac{\alpha^2\tau_s}{(\tau+\tau_s)^2} + \frac{\beta^2}{\tau_\epsilon}\right]\right\}.
\end{aligned} \tag{8}
$$

Since any contract with the same value for $\left(\frac{\tau_s}{\tau+\tau_s}\alpha+\beta\right)$ would give the same incentives to the manager, α and β should be determined to reduce the manager's risks

$$
\begin{aligned}
&\min_{\{\alpha,\beta\}} \; \frac{\gamma}{2}\left[\frac{1}{\tau}\left(\frac{\tau_s}{\tau+\tau_s}\alpha+\beta\right)^2 + \frac{\alpha^2\tau_s}{(\tau+\tau_s)^2} + \frac{\beta^2}{\tau_\epsilon}\right], \\
&\text{subject to } \; h\cdot\left(\frac{\tau_s}{\tau+\tau_s}\alpha+\beta\right) = \mu.
\end{aligned} \tag{9}
$$

Thus, we can first solve for the optimal α and β for any given level of μ, and then solve for the optimal level of μ.

The optimal incentive contract we obtain in this way is described by the following proposition.

Proposition 1 *When the manager is sufficiently risk-averse that $\gamma > \frac{h^2\tau^2}{\tau+\tau_s+\tau_\epsilon}$, the optimal level of effort is given by*

$$
\mu = \frac{h^3}{h^2 + \gamma\left(\frac{1}{\tau} + \frac{1}{\tau_s+\tau_\epsilon}\right)}
$$

and the optimal weighting of short and long term stock participation is

$$
\left\{
\begin{array}{rcl}
\alpha^\dagger &=& \frac{(\tau_s+\tau)h^2}{(\tau_s+\tau_\epsilon)\left[h^2+\gamma\left(\frac{1}{\tau}+\frac{1}{\tau_s+\tau_\epsilon}\right)\right]}, \\
\beta^\dagger &=& \frac{\tau_\epsilon h^2}{(\tau_s+\tau_\epsilon)\left[h^2+\gamma\left(\frac{1}{\tau}+\frac{1}{\tau_s+\tau_\epsilon}\right)\right]},
\end{array}
\right.
$$

When the manager is not too averse to risk, so that $\gamma \le \frac{h^2\tau^2}{\tau+\tau_s+\tau_\epsilon}$, the optimal level of effort is given by

$$
\mu = \frac{h^3\tau^2\tau_\epsilon + h\gamma\tau_s(\tau+\tau_s+\tau_\epsilon)}{h^2\tau^2\tau_\epsilon + \gamma(\tau+\tau_s+\tau_\epsilon)(\tau+\tau_s)}
$$

and the optimal weighting of short and long term stock participation is

$$\begin{cases} \alpha^{\dagger} &= \frac{\gamma(\tau+\tau_s)(\tau+\tau_s+\tau_\epsilon)}{h^2\tau^2\tau_\epsilon+\gamma(\tau+\tau_s)(\tau+\tau_s+\tau_\epsilon)}, \\ \beta^{\dagger} &= \frac{h^2\tau^2\tau_\epsilon}{h^2\tau^2\tau_\epsilon+\gamma(\tau+\tau_s)(\tau+\tau_s+\tau_\epsilon)}, \end{cases}$$

For both cases, the cash component $\delta^{\dagger}$ is chosen so that the manager's participation constraint in equation (6) is binding.
Proof: see the Appendix.

In the case where the manager is not very risk-averse the constraint $\alpha + \beta \leq 1$ is binding because the manager has a high risk tolerance. Indeed, as one would expect in this case, it is optimal to effectively 'sell the firm' to the manager and let her take on all the risk. This solution involves only a small insurance cost but provides maximal effort incentives. Note, however, the difference in the optimal contract relative to the standard result that the firm should be sold entirely to the manager when she is risk neutral. Here, when the manager is close to being risk neutral it may be optimal to have her 'own' the entire firm at time 0. However, for diversification reasons she will want to sell part of her holdings at time $t = 1$. When the manager's risk tolerance is low, on the other hand, it is optimal to set $\alpha+\beta < 1$ and to choose α and β to minimize the manager's insurance costs.

5 Optimal CEO compensation in a speculative market

A critical assumption in existing models of executive compensation is that stock markets are informationaly efficient and that stock prices reflect the expected fundamental value of the firm. If stock prices reflect fundamental value and if the CEO's actions affect the firm's long run fundamental value then it seems quite sensible to incentivize the CEO through some form of equity based compensation. But how should CEOs be compensated when stock prices can systematically deviate from fundamental value? This is the question we now address. To be able to analyze this problem, however, we need a model of equilibrium stock prices which systematically depart from fundamentals. We will use a simplified version of Scheinkman and Xiong (2003).

Their model of speculative secondary stock markets involves trading between overconfident investors, who may disagree about the value of the firm. The introduction of overconfident shareholders is the only change we bring to the classical model of the previous section. All investors are still assumed to be risk-neutral, but now they may overestimate the informativeness of the signals s and θ. Investor overconfidence leads to differences in beliefs at $t = 1$ about the firm's terminal value, even if all investors start with the same prior beliefs at $t = 0$. Investors that are overconfident about a positive realization of the signal they observe will want to buy shares from other investors who are either rational or are overconfident with respect to a negative realization of another signal they observed. Thus, this difference in beliefs generates secondary market trading, and, due to the constraint on short-selling all investors face, this also gives rise to a speculative price premium.

In short, overconfidence and differences of opinion combined with limits on short selling give rise to equilibrium prices that may deviate from the firm's fundamentals at $t = 1$. Since these deviations are anticipated at $t = 0$ and priced in by initial shareholders, they also give rise to deviations from fundamental value at $t = 0$. In other words, stock prices at $t = 0$ will reflect both the fundamental value of the firm and a speculative component. Critically, for our purposes, the size of this speculative component can be influenced by inducing the manager to devote more effort to the 'castle-in-the-air project', which is the main source of potential disagreement among investors at $t = 1$.[17]

5.1 Equilibrium asset prices in a speculative market

To model speculative trading, we assume that there are two groups of investors: A and B. Each group starts with the same prior beliefs but may end up with different posterior beliefs due to their overconfidence. Formally, we model overconfidence by assuming that the investors in the two groups disagree on the informativeness of signal θ, with group-A investors treating the precision of the signal as $\phi^A\tau_\theta$, and group-B investors as $\phi^B\tau_\theta$. Under this formalization, if $\phi^A \to 1$ and $\phi^B \to 1$ we are back in the case of efficient markets with no overconfidence. We shall allow for both differences between ϕ^A and ϕ^B as well as overconfidence by both groups ($\phi^A > 1$ and/or $\phi^B > 1$).

[17] An extreme example of such a 'castle-in-the-air' project is Enron's venture into broadband video on demand. This venture, along with the purchase of Blockbuster video, was valued at several billion dollars, while Enron was still perceived as a model company, even though in the end it only generated negligible revenue.

Critically, we also assume that investors in each group are aware of the possible overconfidence of investors in the other group, although their own introspection is not deep enough to lead them to recognize that they themselves might also be overconfident.

To simplify the contracting problem at $t = 0$ we shall assume that all controlling shareholders and the C.E.O. are of the same group, say, group A, and B-investors buy into the firm only at $t = 1$. This assumption allows us to avoid the spurious issue of aggregation of shareholder objectives with different forms of overconfidence. But also, it allows us to avoid modeling explicitly another possible round of trading of shares between A-investors and B-investors at $t = 0$. In effect, we are looking at the firm at $t = 0$, as if it had already gone through an initial round of trading, which resulted in the group which values the firm the most holding all the stock[18].

For simplicity we confine investors' overconfidence to just the signal θ. Investors use the correct precision for signal s. Thus, in accordance with Bayes rule investors in groups A and B share the same posterior belief about u at $t = 1$:

$$\hat{u} = \hat{u}^A = \hat{u}^B = h\mu + \frac{\tau_s}{\tau_s + \tau}(s - h\mu).$$

In the remainder of this paper we shall use superscripts A and B to denote the variables associated with the respective groups of investors.

At $t = 1$, the investors' posteriors on v differ as follows:

$$\hat{v}^A = \frac{\phi^A \tau_\theta}{\tau_z + \phi^A \tau_\theta}\theta\omega = \frac{\phi^A}{\eta + \phi^A}\theta\omega,$$

$$\hat{v}^B = \frac{\phi^B \tau_\theta}{\tau_z + \phi^B \tau_\theta}\theta\omega = \frac{\phi^B}{\eta + \phi^B}\theta\omega.$$

Thus, the difference in posterior beliefs is

$$\hat{v}^A - \hat{v}^B = \left(\frac{\phi^A}{\eta + \phi^A} - \frac{\phi^B}{\eta + \phi^B}\right)\theta\omega. \tag{10}$$

[18] By assuming that the CEO and shareholders belong to the same group we are ruling out interesting and relevant contracting situations at $t = 0$ where a more optimistic CEO contracts with more sceptical shareholders. In such a situation it is likely that the optimal incentive scheme will be even more short-term oriented, as shareholders may then benefit from rewarding the CEO with what in their eyes is overvalued stock.

This difference in investors' beliefs induces stock trading at $t = 1$: A-investors sell their shares to B-investors when they have higher posteriors, and vice versa. Under risk-neutral preferences, one would then expect to see unbounded bets between overconfident investors. We rule out such bets by assuming that investors cannot engage in short-selling. This is a reasonable assumption as, in practice, it is usually difficult and costly to sell stocks short.[19]

When stock selling is limited by short sales constraints, the price of a stock will be driven up to the valuation of the most optimistic investor. Initial shareholders and the CEO (in group A) thus have an option to sell their shares at $t = 1$ to investors in group B when these investors have higher valuations.

Under these assumptions, we are able to derive the following simple expressions for the expected value of the firm at $t = 1$ and $t = 0$. For a given action choice (μ, ω) the equilibrium value of the firm at $t = 1$ to group-A investors is:

$$
\begin{aligned}
V_1 &= \max(\hat{e}^A, \hat{e}^B) = \max(\hat{u}^A + \hat{v}^A, \hat{u}^B + \hat{v}^B) \\
&= h\mu + \frac{\tau_s}{\tau_s + \tau}(s - h\mu) + \hat{v}^A + \max(\hat{v}^B - \hat{v}^A, 0),
\end{aligned}
$$

and the expectation of V_1 at $t = 0$ is

$$V_0 = \mathrm{E}_0^A[V_1] = h\mu + \mathrm{E}_0^A[\max(\hat{v}^B - \hat{v}^A, 0)].$$

That is, the value of the firm at $t = 0$ now also includes the value of the option to sell to group-B investors, $\mathrm{E}_0^A[\max(\hat{v}^B - \hat{v}^A, 0)]$.

This option is analogous to a standard financial option, except that its underlying asset is now the difference in beliefs: $\hat{v}^B - \hat{v}^A$. From equation (10) we note that $(\hat{v}^B - \hat{v}^A)$ has a normal distribution with a mean of zero and a standard deviation of[20]:

$$\left|\frac{\phi^A}{\eta + \phi^A} - \frac{\phi^B}{\eta + \phi^B}\right| \omega l \sqrt{1 + \eta/\phi^A}$$

[19] What is important for our analysis is that there are some limits on short sales. Setting these limits to zero is a technical convenience. Several empirical studies, *e.g.* Jones and Lamont (2002), D'Avolio (2002), and Geczy, Musto and Reed (2002), have documented that it is costly to short-sell stocks, especially for over-valued tech stocks in the recent "bubble" period.

[20] Recall that $\theta = z + \varepsilon_\theta$, where z and ε_θ are normally distributed random variables with mean zero and respective variances l^2 and ηl^2. But, group-A investors are themselves overconfident with respect to θ and believe that ε_θ only has a variance of $\eta l^2/\phi^A$.

Now, observe that the expected value of an option, $\max(0, y)$, for a random variable y with Gaussian distribution $y \sim N(0, \sigma_y^2)$ is given by

$$\mathrm{E}[\max(0, y)] = \int_0^\infty y \frac{1}{\sqrt{2\pi\sigma_y^2}} e^{-\frac{y^2}{2\sigma_y^2}} dz = \frac{\sigma_y}{\sqrt{2\pi}}.$$

Therefore, the value of the firm at $t = 0$ takes the following expression:

Proposition 2 *The equilibrium value of the firm at $t = 0$, given the effort vector (μ, ω), is:*

$$V_0 = h\mu + Kl\omega, \tag{11}$$

with

$$K = \frac{1}{\sqrt{2\pi}} \left| \frac{\phi^A}{\eta + \phi^A} - \frac{\phi^B}{\eta + \phi^B} \right| \sqrt{1 + \eta/\phi^A}. \tag{12}$$

Proof: See the discussion above.

Thus, a critical difference with the value under efficient markets considered before is that now the stock price at $t = 0$ is also an increasing function of ω, while before the gross stock valuation was independent of ω. Notice that in the limit, when ϕ^A and ϕ^B are both approaching 1, the stock price is independent of ω, as before. In other words, in the presence of overconfident investors, the value of the 'castle-in-the-air' project to initial shareholders increases because of the option to sell to group-B shareholders at $t = 1$[21]. The parameter K measures the extent to which the volatility of the castle-in-the-air project is priced in and can be referred to as the *speculative coefficient*. As can be seen from Proposition 2, this coefficient K is affected both by the degree of overconfidence of investors and by the informativeness of the signal.

This change in the valuation of the firm at $t = 0$ is the key distortion introduced by speculative markets. As we shall illustrate below, this systematic bias in stock prices, far from discouraging rational shareholders from exposing the CEO to stock based remuneration, will instead induce them to put more weight on short run stock performance. Indeed, incumbent shareholders would now be willing to sacrifice some long-term value in μ for a higher ω, in order to exploit short-term speculative profits.

[21] Note that if investors were also overconfident with respect to signal s then the speculative option value would be attached to the long-run venture u as well. Overconfidence and speculative markets would then give rise to another inefficiency: overinvestment in u.

5.2 The CEO's problem

Under any incentive contract $\{a, b, c\}$ the market value of the firm at $t = 1$ is now given by:

$$p_1 = \max\ \{\mathrm{E}_1^A[e - (ap_1 + be + c)], \mathrm{E}_1^B[e - (ap_1 + be + c)]\},$$

or,

$$p_1 = \frac{1-b}{1+a}\left(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}\right) - \frac{c}{1+a}.$$

Making the same change of variables as before,

$$\alpha = \frac{a}{1+a}(1-b), \quad \beta = b, \quad \delta = \frac{c}{1+a}$$

we then have

$$p_1 = (1-\alpha-\beta)\left(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}\right) - \delta. \tag{13}$$

and

$$p_0 = (1-\alpha-\beta)\mathrm{E}_0^A[\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}] - \delta. \tag{14}$$

Given a contract $\{\alpha, \beta, \delta\}$ the manager then chooses her best actions by solving[22]:

$$\max_{\mu,\omega}\ \mathrm{E}_0^A\left[\alpha\left(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}\right) + \beta e + \delta\right] - \frac{1}{2}(\mu+\omega)^2 - \frac{\gamma}{2} Var_0^A\left[\alpha\left(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}\right) + \beta e\right] \tag{15}$$

Initial shareholders, thus, choose $\{\alpha, \beta\}$ to maximize the firm's net expected value subject to the manager's incentive constraint in equation (15) and her participation constraint. Substituting for $\hat{u}$, $\hat{v}^A$ and $\hat{v}^B$ into equation (13), we obtain the following expression for equilibrium share price at $t = 1$:

$$\begin{aligned} p_1 \quad &= \quad (1-\alpha-\beta)\left[h\mu^* + \frac{\tau_s}{\tau_s+\tau}(s - h\mu^*)\right] \\ &\quad +(1-\alpha-\beta)\omega\max\left(\frac{\phi^A\theta}{\eta+\phi^A}, \frac{\phi^B\theta}{\eta+\phi^B}\right) - \delta. \end{aligned}$$

Next, by substituting for p_1 in the manager's compensation formula $W = ap_1 + be + c$ we get the following expression for the manager's mean compensation and its variance.

[22] As the CEO is risk-averse she will always sell all her non-vested shares at $t = 1$.

Lemma 3 *Given the manager's effort choice* (μ, ω) *and the choice anticipated by investors* (μ^*, ω^*)*, the manager's expected compensation is*

$$\alpha h\mu^* + \frac{\alpha\tau_s}{\tau_s + \tau} h(\mu - \mu^*) + \alpha K l\omega + \beta h\mu + \delta$$

with the coefficient K *given in equation (12). The variance of the manager's compensation is*

$$\frac{1}{\tau}\left(\frac{\alpha\tau_s}{\tau_s+\tau} + \beta\right)^2 + \frac{1}{\tau_s}\frac{\alpha^2\tau_s^2}{(\tau_s+\tau)^2} + \frac{\beta^2}{\tau_\varepsilon} + \Sigma l^2\omega^2$$

with coefficient

$$\begin{aligned}\Sigma &= \frac{1}{2}\left[\left(\frac{\alpha\phi^A}{\eta+\phi^A} + \beta\right)^2 + \left(\frac{\alpha\phi^B}{\eta+\phi^B} + \beta\right)^2 + \frac{\eta\alpha^2}{\phi^A}\left(\frac{{\phi^A}^2}{(\eta+\phi^A)^2} + \frac{{\phi^B}^2}{(\eta+\phi^B)^2}\right)\right. \\ [0.1in] & \left. -\frac{(\eta+\phi^A)\alpha^2}{\pi\phi^A}\left(\frac{\phi^A}{\eta+\phi^A} - \frac{\phi^B}{\eta+\phi^B}\right)^2\right] \qquad (16)\end{aligned}$$

Proof: See Appendix.

Using this lemma we can rewrite the manager's optimization problem as follows:

$$\max_{\mu,\omega} \;\; \left(\frac{\alpha\tau_s}{\tau_s+\tau} + \beta\right) h\mu + \alpha K l\omega - \frac{1}{2}(\mu+\omega)^2 - \frac{\gamma}{2}\Sigma l^2\omega^2.$$

It is easy to see from this formulation that the manager's marginal return to increasing the scale, ω, of the 'castle-in-the-air' project is increasing in the coefficient K. Moreover, K itself is increasing in

$$\left|\frac{\phi^A}{\eta+\phi^A} - \frac{\phi^B}{\eta+\phi^B}\right|,$$

the difference in overconfidence of investors. In other words, it is immediately apparent from this expression that the return to scaling up the speculative project is increasing in the divergence of overconfidence among investors.

To see this more explicitly, we solve the manager's optimization problem under an arbitrary contract $\{\alpha, \beta, \delta\}$ and obtain the following characterization:

Proposition 4 *Given a compensation contract* $\{\alpha, \beta, \delta\}$*, the manager's best-response is described by the following three situations:*

1) Fundamentalist:

$$\omega = 0 \text{ and } \mu = h\left(\frac{\alpha\tau_s}{\tau_s+\tau} + \beta\right)$$

when $\alpha K l \leq h\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)$,

2) Short-termist:

$$\begin{aligned}\omega &= \frac{\alpha K}{\gamma\Sigma l}-\frac{h}{\gamma\Sigma l^2}\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)>0 \quad \textit{and} \\ \mu &= h\left(1+\frac{1}{\gamma\Sigma l^2}\right)\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)-\frac{\alpha K}{\gamma\Sigma l}\geq 0\end{aligned}$$

when $h\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)<\alpha K l \leq h\left(1+\gamma\Sigma l^2\right)\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)$,

3) Purely speculative:

$$\omega=\frac{\alpha K l}{1+\gamma\Sigma l^2} \textit{ and } \mu=0,$$

when $\alpha K l > h\left(1+\gamma\Sigma l^2\right)\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)$.

Proof: See Appendix.

Because she is averse to risk, the CEO faces a lower marginal cost of effort on μ than on ω. More explicitly, her marginal cost of action μ is only $(\mu+\omega)$ while her marginal cost on ω is $[(\mu+\omega)+\gamma\Sigma l^2\omega]$. Therefore, it only pays the manager to engage in short-termist behavior (by raising ω above zero) if the marginal return on the castle-in-the-air project exceeds that of the long-term project, or equivalently if

$$\alpha K l > h\cdot\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right).$$

A sufficient condition for the manager not to engage in any castle-in-the-air activity is that $Kl<\frac{h\tau_s}{\tau_s+\tau}$, which holds when K or l are small, or when h is large. That is, when there is either little speculative motive among investors or it is difficult to scale up v, or it is easy to improve fundamentals.

In contrast, in a speculative bubble, when K is large (say, $Kl>\frac{h\tau_s}{\tau_s+\tau}$), the CEO would want to pursue such a short-termist strategy provided that her short-term stock holdings α is sufficient large relative to her long-term holdings β.

In the extreme case when the marginal return on raising ω exceeds that of μ, even after adjusting for the risk premium, the CEO would only pursue the castle-in-the-air project.

5.3 The shareholders' problem

The general form of shareholders' constrained optimization problem is the same as before. They choose $\{\alpha, \beta, \delta\}$ to maximize the market value of the firm at $t = 0$ subject to the manager's incentive and participation constraints:

$$\max_{\{\alpha,\beta,\delta\}} p_0 = \max_{\{\alpha,\beta,\delta\}} \ (1 - \alpha - \beta)(h\mu + Kl\omega) - \delta \tag{17}$$

subject to:

$$\max_{\mu,\omega} \alpha(h\mu + Kl\omega) + \beta h\mu - \frac{1}{2}(\mu + \omega)^2 - \frac{\gamma}{2} Var(W) + \delta \geq \bar{W}$$

At the optimum the individual rationality constraint is binding and we can substitute for δ to obtain the following unconstrained problem:

$$\max_{\alpha,\beta} \ h\mu(\alpha,\beta) + \alpha Kl\omega(\alpha,\beta) - \frac{1}{2}(\mu(\alpha,\beta) + \omega(\alpha,\beta))^2 - \frac{\gamma}{2}\Sigma l^2 \left(\omega(\alpha,\beta)\right)^2$$

$$-\frac{\gamma}{2}\left[\left(\frac{\alpha\tau_s}{\tau_s + \tau} + \beta\right)^2 / \tau + \frac{\alpha^2 \tau_s}{(\tau_s + \tau)^2} + \beta^2/\tau_\epsilon\right] - \bar{W}, \tag{18}$$

where $\mu(\alpha, \beta)$ and $\omega(\alpha, \beta)$ satisfy the first-order conditions of the CEO's optimization problem described in Proposition 4.

Although the shareholders' problem is conceptually identical to the previous one, it is more involved technically. In particular, due to the nonlinearity in the objective function, an analytical solution for the optimal contract $\{\alpha, \beta, \delta\}$ is not generally available. However, it is easy to see that an optimal contract always exists. First, the feasible set of contracts $\{\alpha, \beta\}$ is bounded and closed. Second, the objective in equation 18 is continuous over this set of contracts. Therefore, standard considerations guarantee that:

Proposition 5 *There always exists at least one optimal contract that maximizes the objective of initial shareholders in the set $\alpha \geq 0, \beta \geq 0$ and $\alpha + \beta \leq 1$.*

We are only able to explicitly characterize the optimal contract in the special case where the CEO is risk-neutral. In this extreme case the optimal contract is as follows:

Proposition 6 *When the manager is risk neutral ($\gamma = 0$), the optimal contract induces either: a) Purely speculative behavior by the manager, when $Kl > h$. In that case the optimal contract*

is such that $\alpha = 1$ and $\beta = 0$, and the resulting managerial actions are $\mu = 0$ and $\omega = Kl$, or b) fundamentalist behavior, when $Kl \leq h$. In that case the optimal contract is such that $\alpha = 0$ and $\beta = 1$, and the resulting managerial actions are $\mu = h$ and $\omega = 0$.
Proof: see Appendix.

Thus, in accordance with standard agency theory, when the manager is risk-neutral it is optimal to make her a 'residual claimant' on the firm's cash-flow (see Jensen and Meckling 1976). Interestingly, however, in our set-up with speculative capital markets this is not the final word on the optimal contract. It remains to determine whether the manager should be encouraged to have an extreme speculative short-termist perspective or a fundamentalist long-term one. When investors have a high degree of overconfidence so that the speculative option value at $t = 0$ is high $(Kl > h)$ then it is optimal to induce the manager to focus on the short-term strategy by allowing her to sell all her shares at $t = 1$. In contrast, when investors are likely to be relatively less speculative, so that $Kl \leq h$, the manager will choose to focus on the long-term fundamental value of the firm and will sell no shares at $t = 1$.

This special case with a risk-neutral CEO illustrates in a simple way one basic effect of speculative trading generated by investor overconfidence on the CEO incentive contract. However, in this case there is no real agency costs.

5.4 Risk averse C.E.O.

Even though a complete characterization of the optimal contract when the manager is risk averse is not available, it is possible to determine a sufficient condition on overconfidence of investors under which the manager engages in short-termist behavior, $\omega \neq 0$. We give a sufficient condition here for the special case where only group-B investors are overconfident. The reason why we focus on this case is to emphasize the observation that: i) even under an incentive contract that is optimal given an efficient secondary market, the C.E.O. may engage in short-termist behavior (by setting $\omega > 0$) when there is an episode of overconfidence giving rise to a bubble; and ii) when such an episode arises it may be in the interest of shareholders to reinforce the manager's incentives towards short-termism by weighing her stock compensation more heavily towards short-term compensation.

When $\phi^A = 1$, the speculative coefficient K increases with the overconfidence level of group-B investors:

$$K = \sqrt{\frac{\eta+1}{2\pi}} \left| \frac{\phi^B}{\eta+\phi^B} - \frac{1}{\eta+1} \right|.$$

Also, when $\phi^B = 1$, the optimal managerial contract is the one given in Proposition 1. Now, consider the following question: given that the manager and the incumbent shareholders are fully rational, how does the presence of overconfident noise traders (group-B investors) affect the firm and the managerial contract? Although the firm could always choose to ignore the overconfident noise traders in the market, Proposition 7 below provides a sufficient condition on the overconfidence of these traders under which shareholders optimally adopt a managerial contract that induces some short-termist behavior from the manager.

Proposition 7 *Let $(\alpha^\dagger, \beta^\dagger, \delta^\dagger)$ be a contract (as specified in Proposition 1) that is optimal when secondary markets are efficient. If the overconfidence of group-B investors ϕ^B is sufficiently large that*

$$Kl > h, \quad \text{and} \quad \left(Kl - \frac{h\tau_s}{\tau_s+\tau} \right) \alpha^\dagger > h\beta^\dagger, \tag{19}$$

then the optimal managerial contract (α, β, δ) given overconfidence level ϕ^B induces short-termist behavior: $\omega > 0$.
Proof: see Appendix.

When the C.E.O. finds it optimal to set $\omega > 0$ given the contract $(\alpha^\dagger, \beta^\dagger, \delta^\dagger)$ then *a fortiori* initial shareholders should value $\omega > 0$ even more, as they are risk neutral. As it will become apparent from the numerical solutions that follow, the optimal contracting problem in the presence of speculative markets does not yield simple comparative statics results. This is why we expect that a complete analytical characterization of the optimal contract is only obtainable in special cases.

The numerical solutions reported below have been obtained using a standard MATLAB routine. To contrast the numerical solutions with proposition 7 we continue to assume that $\phi^A = 1$ and begin by discussing how the CEO's risk-aversion affects the optimal contract and equilibrium actions.

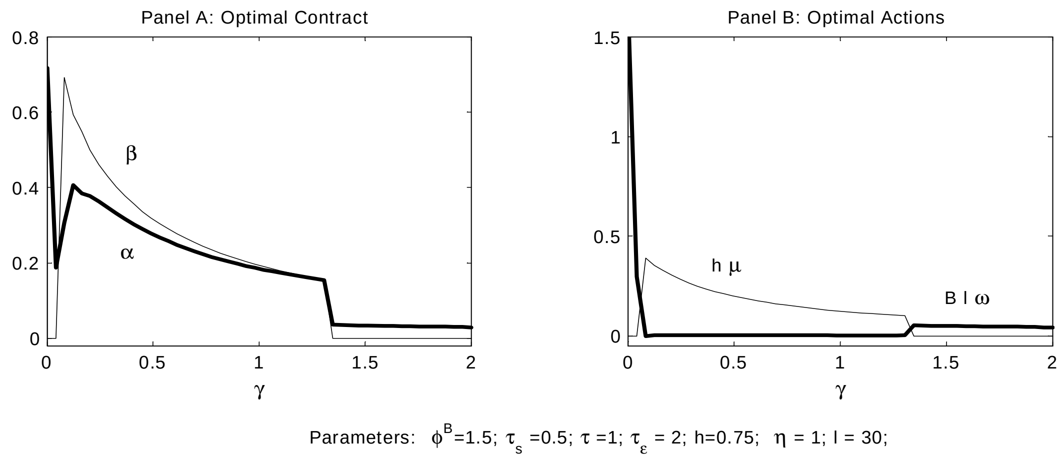


Figure 1: Optimal contract and actions as a function of γ, for intermediate ϕ^B.

5.4.1 CEO risk aversion γ

When secondary markets are efficient, the optimal contract puts positive weight on both short-term and long-term performance since both are informative about the agent's action choice. In addition, exposure to both types of risk provides diversification benefits to the CEO. In the presence of speculative distortions, we expect that the optimal contract will put more weight on short-term performance, but otherwise continues to base compensation on both short and long-term performance. As the CEO becomes more risk-averse, we expect that there will be greater benefits to diversification and that therefore there will be a more balanced weighting on both performance measures. For high coefficients of risk aversion, we expect the manager to put more weight on the less risky long-term value of the firm.

These predictions are generally borne out by our numerical solutions. However, these solutions also highlight the subtle effects of risk-aversion on short-termist speculative incentives. We provide one illustration below in Figure 1 for an intermediate value of ϕ^B.[23]

This Figure reveals the somewhat surprising finding that the manager is induced to focus exclusively on the short-term project *both* when her coefficient of risk aversion is very small (less than 0.1 in the illustrated example) and when it is very large (above 1.3 in our example).

[23] In a previous version we also report solutions for high and low values of ϕ.

When the manager's risk aversion increases above 0.1 but remains less than 1.3, she switches to pursuing only the firm's fundamental value but her compensation is based on a combination of long-term and short-term stock performance. Finally, when her coefficient of risk aversion γ increases beyond 1.3, she switches back to pursuing only the short-term speculative project and her compensation is again only based on the firm's short-term performance. The figure provides some clues to the reasons for this non-monotonic pattern. When the manager's coefficient of risk-aversion increases, it becomes more and more expensive for shareholders to induce her to pursue the long-term value of the firm. Therefore, in equilibrium the manager scales back her effort and chooses lower μ. At some point, the overall benefit of pursuing the long-term value in this way is so small that shareholders prefer to switch to the speculative strategy. This explains the non-monotonic relation between γ and (μ, ω). This figure illustrates the complex interaction between several effects and the difficulties in characterizing a complete analytical solution for the optimal contract.

5.4.2 Overconfidence ϕ^B

It is natural to expect that the optimal contract will put more weight on short run performance, the higher the overconfidence of group-B investors ϕ^B. More precisely, as ϕ^B becomes larger, posterior beliefs between the two groups of investors at $t = 1$ become more dispersed. Therefore the speculative component in stock prices, or the value of the resale option, becomes larger. This should encourage shareholders to take a more short-termist outlook. Similarly, we expect shareholders to give the CEO a more short-term weighted compensation contract, which will induce her to put more effort into the castle-in-the-air project (a higher ω). Figure 2 shows how the optimal contract and optimal actions vary with ϕ^B. When ϕ^B is small the optimal contract puts weights on short and long term performance. The optimal contract is close to the equilibrium contract obtained in the standard case ($\phi^B = 1$.) For high ϕ^B, on the other hand, the optimal contract only uses short term stock participation, as expected.

5.4.3 The manager's return on effort h and l

The comparative statics results with respect to marginal return on effort on the fundamental project are as one would expect. The higher is h, the higher will be the equilibrium effort μ.

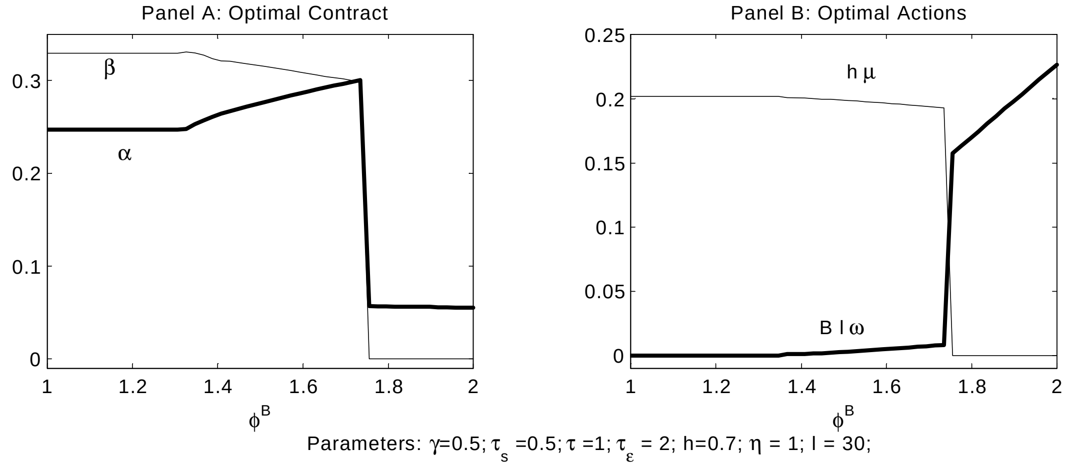


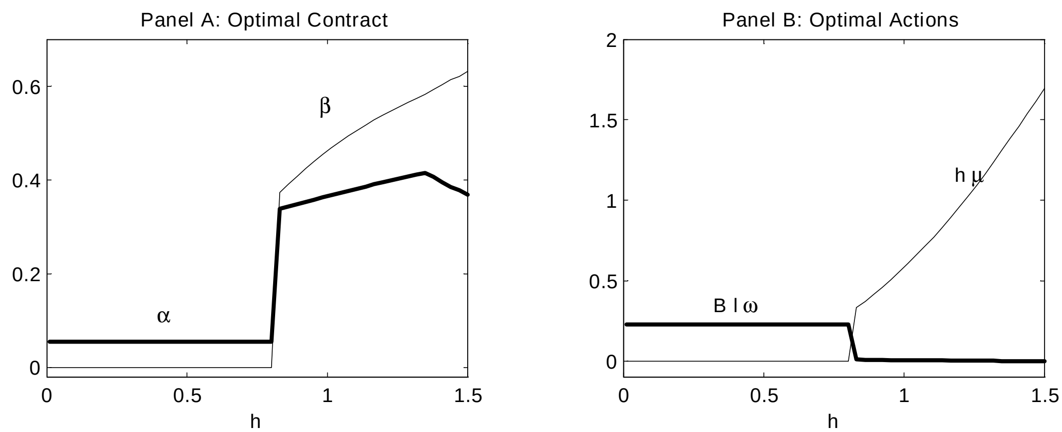
Figure 2: Optimal contract and actions as a function of ϕ.

This is can be seen clearly in Figure 3 below.

Similarly, when the manager's effort on the castle-in-the-air project are more effective in terms of generating speculative price component (as measured by l), shareholders induce the manager to put more effort in that project, provided that group-B investors are sufficiently overconfident. This is illustrated in Figure 4 for $\phi^B = 2$.

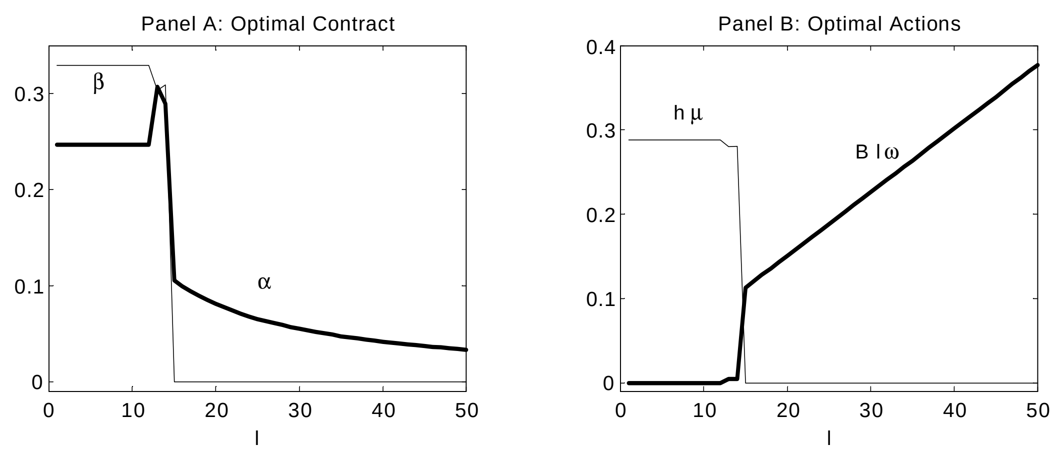
5.4.4 Fundamental risk τ, τ_s and τ_ϵ

Given a fixed compensation contract $\{\alpha, \beta, \delta\}$ the CEO is likely to increase her effort μ when the precisions τ, τ_s and τ_ϵ increase, since investment in the long-term project exposes her to less risk. In other words, the cost to shareholders of inducing the CEO to supply a given level of effort μ is reduced as these precisions increase. Therefore we would expect shareholders to 'buy' more effort from the CEO, which means that $\alpha + \beta$ should increase. Figure 5 illustrates this point. This figure also shows that μ increases with τ. This is natural, since for τ small the long term project is very risky, and hence the optimal contract induces the manager to focus on the short-term project. For higher values of τ, the underlying risk on u is reduced and the manager is induced to switch to pursuing the long-term fundamental value of the firm. But the contract still provides for some diversification of risk by putting positive weight on both short-term and



Parameters: γ=0.5; ϕ^B=2; τ =1; τ_s = 0.5; τ_ε = 2; η = 1; l = 30;

Figure 3: Optimal contract and actions as a function of h.



Parameters: γ=0.5; ϕ^B=2; τ_s =0.5; τ_ε= 2; τ =1; h=0.7; η=1;

Figure 4: Optimal contract and actions as a function of l.

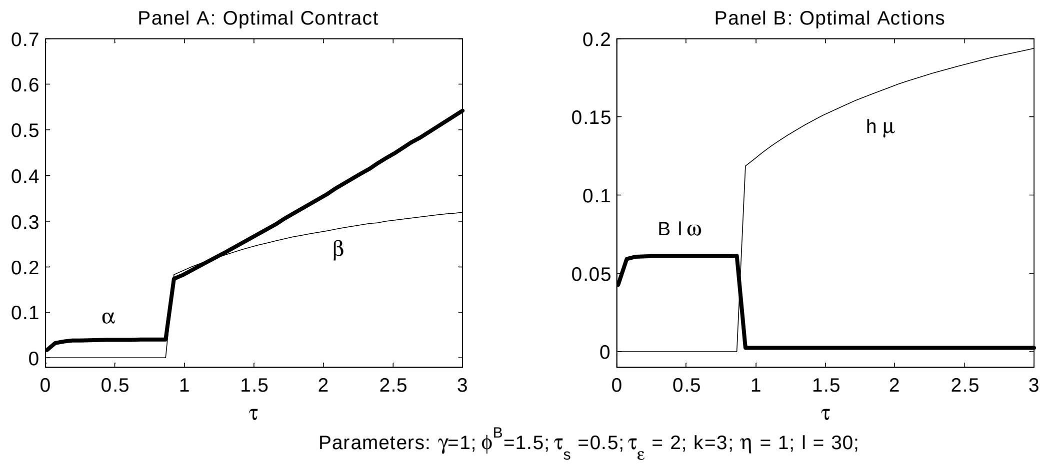


Figure 5: Optimal contract and actions as a function of τ.

long-term performance.[24]

6 Discussion and Empirical Implications

In this paper we used an optimal contracting or agency approach to explain the structure of CEO compensation, making only one substantive change to the standard theory. Instead of modelling stock markets as efficient, we have allowed for investor overconfidence and consequently speculative deviations of stock prices from fundamentals. We have shown how the introduction of a speculative component in the stock price creates a distortion in CEO compensation leading to a short-term orientation. For some parameter values CEOs are encouraged to pursue short-term speculative projects even at the expense of long-term fundamental value.

Our analysis has potentially important implications for corporate governance and the regulation of CEO stock-option plans. Reacting to the recent corporate scandals, many commentators have argued that the current structure of CEO pay in the US cannot be rationalized on the basis of agency theory (see most notably, Bebchuk, Fried and Walker 2002). These commentators argue that the main problem with CEO compensation in the US is a failure of corporate governance and call for a regulatory response to strengthen boards of directors, as well as audit and

[24]In an earlier version we showed that the comparative statics with respect to τ_s and τ_ε are similar to those with respect to τ.

remuneration committees.

If, as we propose, the explanation for the corporate failures is in part related to speculative stock markets, and if the recent CEO compensation excesses are partly a by-product of the technology bubble, then different policy implications may well emerge. Thus, for example, further strengthening of boards may not make a major difference. On the other hand, regulatory limits on CEOs' ability to unwind their own stock holdings in short horizons (whether desirable or not) do provide a more effective deterrent to the pursuit of short-term strategies.

Another frequently discussed proposal is to force firms to expense option grants. This measure seems to aim at two different effects. The first is to increase the clarity of corporate accounting. The second is to increase the cost of performance based compensation. To the extent that the non-expensing of stock options provides a greater subsidy to long-run stock options (with greater time to expiration) relative to options with short horizons, expensing of stock options may increase the cost of providing incentives for managers to pursue strategies that maximize fundamentals. Hence the accounting change concerning option expensing may have a perverse effect on manager's incentives.

An interesting question that our analysis raises is when are firms likely to encourage such short-termist behavior. Our comparative statics analysis provides some helpful hints. First, we expect short-termist behavior to be more likely in new industries where it is likely to be harder to evaluate the fundamental profitability of the industry and therefore there is likely to be substantial disagreement among investors. In terms of our model, firms in such industries would have a high l parameter, and a low precision τ. In addition, short-termism should be more prevalent in periods of high investor overconfidence.

Second, firms with dwindling business-lines (low h parameter in our model) would also be more prone to pursue castle-in-the-air strategies. Third, in our model we assumed that stocks are perfectly liquid. If, however, stocks are not perfectly liquid and trade for less than their expected final payoff, short term strategies are less effective. Therefore, we expect that firms with illiquid stocks are less likely to pursue short-term strategies.

In our model all initial shareholders are identical. In reality managerial compensation contracts reflect the motives of shareholders that influence the compensation committees. Frequently these are institutions. In this case our model would predict a correlation between institutional shareholder turnover and the firm manager's short-termist behavior. Indeed, Bushee (1998) provides some evidence of this type. He shows that managers in firms where a large proportion of institutional owners have a high turnover tend to reduce R&D expenses in order to boost short-term earnings.

7 Does a long-term oriented board remedy short-termism?

Our analysis has highlighted how initial shareholders may want to induce managerial short-termism as a way of increasing the value of their option to sell to more optimistic shareholders at $t = 1$. A natural question then arises whether long-term oriented shareholders, or fiduciary duties for board members to maximize the long-run value of the firm, would remedy this short-termism in firms. We address this question here by considering the following more general objective function for initial shareholders:

$$\max_{\{\alpha,\beta,\delta\}} \;(1-\alpha-\beta)[\lambda E_0[p_1] + (1-\lambda)E_0[e]] - \delta$$

where, $\lambda \in [0, 1]$ denotes the probability that an initial shareholder will be present in the market at $t = 1$. Alternatively, λ can also be interpreted as the fraction of shareholders who are able to trade their shares at $t = 1$. When $\lambda = 1$, all the shareholders are able to trade, and the objective is the same as the one we have considered so far. When $\lambda = 0$ shareholders hold their shares until $t = 2$. It would appear that in this latter case shareholders would not want to take advantage of potential speculative episodes in $t = 1$ and would only want to maximize the long-run value of the firm.

As it turns out, the matter is more subtle than that. Even when shareholders (as represented by their board) commit to hold their shares for the long-run, it may still be in their interest to encourage some short-termist behavior by managers, since this may lower the cost of their compensation. The next proposition provides a sufficient condition under which the manager engages in short-termist behavior even when shareholders are fully long-term oriented:

Proposition 8 *Let $(\alpha^\dagger, \beta^\dagger, \delta^\dagger)$ be the optimal contract given an efficient market, as specified in Proposition 1. If ϕ^B is sufficiently large that*

$$\alpha^\dagger Kl > h, \quad \textit{and} \quad \left[\alpha^\dagger + 2\lambda(1-\alpha^\dagger-\beta^\dagger)\right] Kl > h\left[2 - \left(\frac{\alpha^\dagger \tau_s}{\tau_s+\tau} + \beta^\dagger\right)\right], \qquad (20)$$

then the resulting optimal managerial contract (α, β, δ) *chosen by a board with long term orientation* $(1-\lambda)$ *would still generate some short-termist behavior:* $\omega > 0$.
Proof: see Appendix.

Proposition 8 shows that in a speculative market, even a long-term oriented board (with $\lambda = 0$) might want to adopt a managerial contract to motivate some short-termist effort from the manager. Admittedly, it takes larger differences in overconfidence between the two groups before a short-termist behavior becomes attractive.

It appears intuitive that the lower λ is the lower are shareholder's incentives to pursue a short-termist strategy. Indeed, it is straightforward to prove that this is indeed the case in the first-best problem, where shareholders can directly choose μ and ω. Unfortunately, however, in the second-best problem, where μ and ω are hidden actions it is not possible to establish generally that ω is increasing in λ. This is not surprising, as simple comparative statics results in contracting problems with moral hazard are usually not available. We have, therefore, explored this issue numerically and report how the optimal contract varies with λ in Figure 6 below. As the figure illustrates, an increase in λ has the expected effect. The more likely shareholders are to be actively trading at $t = 1$, the more short-termist the manager's incentives are, and the more attention the manager devotes to the castle-in-the-air project.

The analysis in this section, thus, indeed suggests that if the objective is to reduce the incidence of short-term speculative investments, then one way to achieve this is to have a more long-term oriented board, and to give more control to buy-and-hold investors.

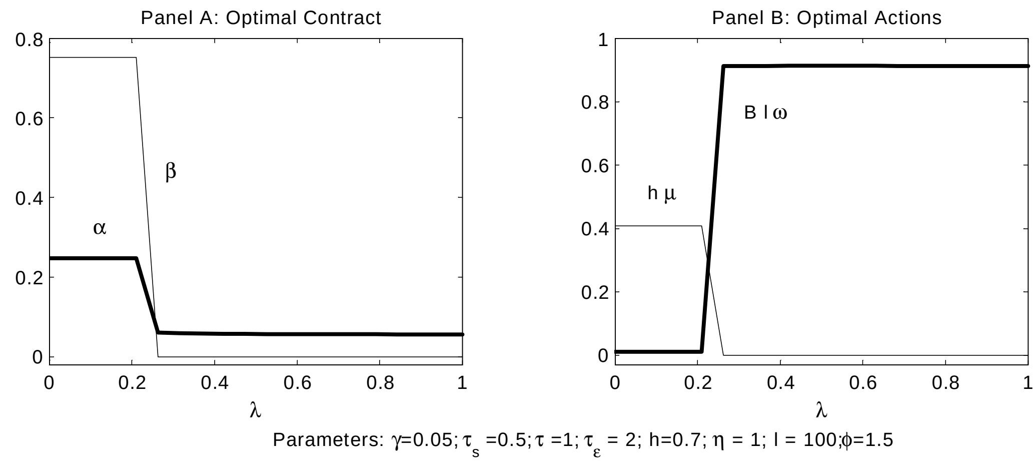


Figure 6: Optimal contract and actions as a function of λ.

A Some Proofs

A.1 Proof to Proposition 1

We denote $x = \mu/h = \frac{\alpha\tau_s}{\tau_s+\tau} + \beta$. Note that $0 \le x \le 1$. For given level of x, investors can determine the combination of α and β:

$$\min \quad \frac{\alpha^2\tau_s}{(\tau_s+\tau)^2} + \frac{\beta^2}{\tau_\epsilon}$$

subject to the constraint that

$$0 \le \beta \le 1, \quad 0 \le \alpha \le (1-\beta).$$

It is immediate to establish the following results: If $x < \frac{\tau_s+\tau_\epsilon}{\tau+\tau_s+\tau_\epsilon}$, the optimal combination is

$$\alpha = \frac{\tau_s+\tau}{\tau_s+\tau_\epsilon}x, \quad \beta = \frac{\tau_\epsilon}{\tau_s+\tau_\epsilon}x.$$

Otherwise, if $x \ge \frac{\tau_s+\tau_\epsilon}{\tau+\tau_s+\tau_\epsilon}$, the constraint $\alpha+\beta \le 1$ is binding and the optimal combination is

$$\alpha = \frac{\tau+\tau_s}{\tau}(1-x), \quad \beta = \frac{\tau+\tau_s}{\tau}x - \frac{\tau_s}{\tau}.$$

Next, we determine the optimal level of x. If $x < \frac{\tau_s+\tau_\epsilon}{\tau+\tau_s+\tau_\epsilon}$, the objective of the shareholders can be derived as

$$L = h^2x - h^2x^2/2 - \frac{\gamma}{2}[x^2/\tau + \alpha^2\tau_s/(\tau_s+\tau)^2 + \beta^2/\tau_\epsilon]$$

It is direct to verify that the maximum of this function is reached at

$$x = \frac{h^2}{h^2 + \gamma\left(\frac{1}{\tau} + \frac{1}{\tau_s + \tau_\epsilon}\right)},$$

which is less than $\frac{\tau_s+\tau_\epsilon}{\tau+\tau_s+\tau_\epsilon}$ if $h^2 \leq \gamma(\tau + \tau_s + \tau_\epsilon)/\tau^2$.

On the other hand, if $x \geq \frac{\tau_s+\tau_\epsilon}{\tau+\tau_s+\tau_\epsilon}$, the objective function can be derived as

$$L = h^2 x - h^2 x^2/2 - \frac{\gamma}{2}\left\{x^2/\tau + \frac{\tau_s}{\tau^2}(1-x)^2 + \frac{[(\tau_s+\tau)x - \tau_s]^2}{\tau^2\tau_\epsilon}\right\},$$

and its maximum is reached at

$$x = \frac{h^2\tau^2\tau_\epsilon + \gamma\tau_s(\tau+\tau_s+\tau_\epsilon)}{h^2\tau^2\tau_\epsilon + \gamma(\tau+\tau_s+\tau_\epsilon)(\tau+\tau_s)}$$

which is larger than $\frac{\tau_s+\tau_\epsilon}{\tau+\tau_s+\tau_\epsilon}$ if $h^2 > \gamma(\tau + \tau_s + \tau_\epsilon)/\tau^2$.

A.2 Proof to Lemma 3

The manager's expected monetary compensation is:

$$\begin{aligned}
& \mathrm{E}_0^A\left[\alpha\left(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}\right) + \beta e + \delta\right] \\
= \;& \alpha h\mu^* + \frac{\alpha\tau_s}{\tau_s+\tau}h(\mu - \mu^*) + \alpha\mathrm{E}_0^A[\max\{\hat{v}^B - \hat{v}^A, 0\}] + \beta h\mu + \delta. \\
= \;& \alpha h\mu^* + \frac{\alpha\tau_s}{\tau_s+\tau}h(\mu - \mu^*) + \alpha K l\omega + \beta h\mu + \delta
\end{aligned}$$

And the variance of the manager's payoff is:

$$\begin{aligned}
& Var_0^A\left[\alpha\left(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}\right) + \beta e + \delta\right] \\
= \;& Var_0^A\left[\alpha\frac{\tau_s}{\tau_s+\tau}(s - h\mu^*) + \alpha\omega\max\left\{\frac{\phi^A\theta}{\eta+\phi^A}, \frac{\phi^B\theta}{\eta+\phi^B}\right\} + \beta e\right] \\
= \;& Var_0^A\left[\frac{\alpha\tau_s(u+\epsilon_s)}{\tau_s+\tau} + \beta(u+\epsilon)\right] + \omega^2 Var_0^A\left[\alpha\max\left\{\frac{\phi^A}{\eta+\phi^A}(z+\epsilon_\theta), \frac{\phi^B}{\eta+\phi^B}(z+\epsilon_\theta)\right\} + \beta z\right] \\
= \;& \left(\frac{\alpha\tau_s}{\tau_s+\tau} + \beta\right)^2\sigma^2 + \frac{\alpha^2\tau_s^2}{(\tau_s+\tau)^2}\sigma_s^2 + \beta^2\sigma_\epsilon^2 + \Sigma l^2\omega^2
\end{aligned}$$

where Σ is given in equation (16). The first variance is straightforward to derive. To derive the second one, it is important to note that from the manager's perspective (who shares the belief of group-A investors), z and ϵ_θ are independent with variances of l^2 and $\eta l^2/\phi^A$, respectively. The following lemma can be used directly to derive this variance.

Lemma 9 *If a random variable z has a Gaussian distribution $z \sim N(0, \sigma^2)$, then*

$$\mathrm{E}[\max(0, z)] = \frac{\sigma}{\sqrt{2\pi}}.$$

When random variables x and y have independent Gaussian distributions with zero means and variances of σ_x^2 and σ_y^2, respectively, then

$$\begin{aligned} & Var\{\max[a_1(x+y), a_2(x+y)] + bx\} \\ = \; & \frac{1}{2}\left[(a_1+b)^2 + (a_2+b)^2 - \frac{1}{\pi}(a_2-a_1)^2\right]\sigma_x^2 + \frac{1}{2}\left[a_1^2 + a_2^2 - \frac{1}{\pi}(a_2-a_1)^2\right]\sigma_y^2, \quad \text{(A1)} \end{aligned}$$

where a_1 and a_2 be two positive constants.

Proof: Through direct integration, we have

$$\mathrm{E}[\max(0, z)] = \int_0^{\infty} z \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{z^2}{2\sigma^2}} dz = \frac{\sigma}{\sqrt{2\pi}}.$$

Without lose of generality, we assume $a_1 < a_2$. If $a_1(x+y) > a_2(x+y)$, then $x < -y$. Therefore,

$$\begin{aligned} & \mathrm{E}\{\max[a_1(x+y), a_2(x+y)] + bx\}^2 \\ = \; & \int_{-\infty}^{\infty} dy \frac{1}{\sqrt{2\pi}\sigma_y} e^{-\frac{y^2}{2\sigma_y^2}} \left\{ \int_{-\infty}^{-y} dx \frac{1}{\sqrt{2\pi}\sigma_x} e^{-\frac{x^2}{2\sigma_x^2}} [(a_1+b)x + a_1 y]^2 \right. \\ & \left. + \int_{-y}^{\infty} dx \frac{1}{\sqrt{2\pi}\sigma_x} e^{-\frac{x^2}{2\sigma_x^2}} [(a_2+b)x + a_2 y]^2 \right\} \\ = \; & \frac{1}{2}[(a_1+b)^2 + (a_2+b)^2]\sigma_x^2 + \frac{1}{2}(a_1^2 + a_2^2)\sigma_y^2 \end{aligned}$$

where the last equation is calculated from direct expansion. Similarly, we can calculate the mean by

$$\mathrm{E}\{\max[a_1(x+y), a_2(x+y)] + bx\} = \frac{(a_2 - a_1)\sqrt{\sigma_x^2 + \sigma_y^2}}{\sqrt{2\pi}}.$$

Using the previous two equations, we can calculate the variance as given in equation (A1). Q.E.D.

A.3 Proof to Proposition 4

We need to maximize

$$\max_{\mu,\omega} \left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)h\mu+\alpha Kl\omega-\frac{1}{2}(\mu+\omega)^2-\frac{\gamma}{2}\Sigma l^2\omega^2$$

subject to $\mu \geq 0$ and $\omega \geq 0$. We can use Lagrange method:

$$L=\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)h\mu+\alpha Kl\omega-\frac{1}{2}(\mu+\omega)^2-\frac{\gamma}{2}\Sigma l^2\omega^2+\lambda_1\mu+\lambda_2\omega$$

where $\lambda_1 \geq 0$, $\lambda_2 \geq 0$, $\lambda_1\mu = 0$ and $\lambda_2\omega = 0$. The first order conditions are

$$\begin{aligned}\frac{\partial L}{\partial \mu} &= \left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)h-(\mu+\omega)+\lambda_1=0\\ \frac{\partial L}{\partial \omega} &= \alpha Kl-(\mu+\omega)-\gamma\Sigma l^2\omega+\lambda_2=0\end{aligned}$$

Solving these first order conditions under the constraints above, we can directly get the three cases given in the proposition.

A.4 Proof to Proposition 6

For a risk-neutral manager, her optimal actions for a given contract $\{\alpha,\beta\}$ is

$$\begin{aligned}&\text{if } \alpha Kl < h\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right), \quad \mu=h\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right), \quad \omega=0;\\ &\text{if } \alpha Kl \geq h\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right), \quad \mu=0, \quad \omega=\alpha Kl.\end{aligned}$$

This is just a simplified version of Proposition 4 with $\gamma = 0$.

Then, the shareholders' problem is

$$\max_{\alpha,\beta} \; h\mu+(1-\beta)Kl\omega-\frac{1}{2}(\mu+\omega)^2.$$

If $\alpha Kl < h\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)$, by substituting μ and ω into the objective, we have

$$\max_{\alpha,\beta} \; h^2\left[\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)-\frac{1}{2}\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)^2\right].$$

It is easy to see that the maximum is reached at $\frac{\alpha\tau_s}{\tau_s+\tau}+\beta=1$, which is only feasible with $\alpha = 0$ and $\beta = 1$. With this contract, the value of the objective function is $\frac{h^2}{2}$, and the condition for the case $\alpha Kl < h\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)$ is always satisfied.

If $\alpha Kl \geq h\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)$, the objective function becomes

$$\begin{aligned} & \max_{\alpha,\beta} \quad K^2l^2[(1-\beta)\alpha-\alpha^2/2] \\ = & \max_{\alpha,\beta} \quad K^2l^2[(1-\beta)^2/2-(1-\beta-\alpha)^2/2]. \end{aligned}$$

It is easy to see that the maximum of $\frac{K^2l^2}{2}$ is reached at $\alpha=1$ and $\beta=0$. This contract only satisfies the condition of the case, $\alpha Kl \geq h(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta)$, when $Kl \geq \frac{h\tau_s}{\tau_s+\tau}$.

By summarizing these two cases, we have the following optimal contract for a risk-neutral manager: If $Kl \geq h$, $\alpha=1$ and $\beta=0$; Otherwise, $\alpha=0$ and $\beta=1$.

A.5 Proof to Proposition 7

For the given contract, $(\alpha^\dagger,\beta^\dagger,\delta^\dagger)$, we denote the manager's optimal effort choice in an efficient market by $(\omega^\dagger,\mu^\dagger)$. Note that $\omega^\dagger=0$ and $\mu^\dagger=h\left(\frac{\tau_s}{\tau+\tau_s}\alpha^\dagger+\beta^\dagger\right)$ from Proposition 1.

In a speculative market, if the speculative coefficient K is large enough so that $\left(Kl-\frac{h\tau_s}{\tau_s+\tau}\right)\alpha^\dagger > h\beta^\dagger$, Proposition 4 implies that the manager's optimal effort choice (ω,μ) contains a non-zero short-term effort: $\omega>0$. Actually, depending on the exact magnitude of K there might be two cases: the short-termist case and the purely speculative case. It is important to note that, in both cases, the manager's short-term effort would also benefit the incumbent shareholders, whose objective function is given in equation (17).

In the short-termist case when $h\left(\frac{\alpha^\dagger\tau_s}{\tau_s+\tau}+\beta^\dagger\right) < \alpha^\dagger Kl \leq h\left(1+\gamma\Sigma l^2\right)\left(\frac{\alpha^\dagger\tau_s}{\tau_s+\tau}+\beta^\dagger\right)$, it is easy to verify that $\mu+\omega=\mu^\dagger$. Then the manager's objective function under the new effort choice becomes larger:

$$\begin{aligned} (1-\alpha^\dagger-\beta^\dagger)(h\mu+Kl\omega)+\delta^\dagger &= (1-\alpha^\dagger-\beta^\dagger)h\mu^\dagger+\delta^\dagger+(1-\alpha^\dagger-\beta^\dagger)(Kl-h)\omega \\ &\geq (1-\alpha^\dagger-\beta^\dagger)h\mu^\dagger+\delta^\dagger. \end{aligned}$$

In the purely speculative case when $\alpha^\dagger Kl > h\left(1+\gamma\Sigma l^2\right)\left(\frac{\alpha^\dagger\tau_s}{\tau_s+\tau}+\beta^\dagger\right)$, it also direct to verify that

$$\omega=\frac{\alpha^\dagger Kl}{1+\gamma\Sigma l^2} > h\left(\frac{\alpha^\dagger\tau_s}{\tau_s+\tau}+\beta^\dagger\right)=\mu^\dagger.$$

Thus, the incumbent shareholders' objective function is also increased:

$$(1-\alpha^\dagger-\beta^\dagger)Kl\omega^\dagger+\delta^\dagger > (1-\alpha^\dagger-\beta^\dagger)Kl\mu^\dagger+\delta^\dagger > (1-\alpha^\dagger-\beta^\dagger)h\mu^\dagger+\delta^\dagger.$$

In summary, under the conditions in (19) the manager's short-term effort choice improves the welfare of herself and the incumbent shareholders for the optimal contract in an efficient market in which short-termist behavior is not rewarded. Therefore, the equilibrium contract in the new speculative environment must also motivate some short-term effort from the manager.

A.6 Proof to Proposition 8

Our plan for the proof is to show that, for the given contract $(\alpha^\dagger, \beta^\dagger, \delta^\dagger)$, the combined welfare of the shareholders, as given in (**??**), and the CEO can be increased in a speculative market under the conditions in (20) from the corresponding level in an efficient market. The gain comes from allowing the manager to sell early to an over-valued stock market, and both shareholders and the manager can benefit by splitting the gain.

For the given contract, $(\alpha^\dagger, \beta^\dagger, \delta^\dagger)$, we denote the manager's optimal effort choice in an efficient market by $(\omega^\dagger, \mu^\dagger)$. Note that $\omega^\dagger = 0$ and $\mu^\dagger = h\left(\frac{\tau_s}{\tau+\tau_s}\alpha^\dagger + \beta^\dagger\right)$ from Proposition 1. The welfare of the shareholders is

$$L^\dagger_{shareholders} = (1 - \alpha^\dagger - \beta^\dagger)h\mu^\dagger - \delta,$$

the welfare of the manager is

$$L^\dagger_{CEO} = (\alpha^\dagger + \beta^\dagger)h\mu^\dagger + \delta - \frac{1}{2}(\mu^\dagger)^2 - \frac{\gamma}{2}\left[\left(\frac{\alpha^\dagger\tau_s}{\tau_s+\tau} + \beta^\dagger\right)^2/\tau + \frac{(\alpha^\dagger)^2\tau_s}{(\tau_s+\tau)^2} + (\beta^\dagger)^2/\tau_\epsilon\right],$$

and the sum is

$$L^\dagger_{shareholders} + L^\dagger_{CEO} = h\mu^\dagger - \frac{1}{2}(\mu^\dagger)^2 - \frac{\gamma}{2}\left[\left(\frac{\alpha^\dagger\tau_s}{\tau_s+\tau} + \beta^\dagger\right)^2/\tau + \frac{(\alpha^\dagger)^2\tau_s}{(\tau_s+\tau)^2} + (\beta^\dagger)^2/\tau_\epsilon\right] \quad \text{(A2)}$$

In a speculative market under the condition that $\alpha^\dagger Kl > h$, Proposition 4 indicates that the manager will choose some short-term effort with the contract $(\alpha^\dagger, \beta^\dagger, \delta^\dagger)$. We denote the manager's effort choice by $(\omega^\ddagger, \mu^\ddagger)$, which is given in Proposition 4 according to two different cases. The shareholders' welfare is

$$L^\ddagger_{shareholders} = (1 - \alpha^\dagger - \beta^\dagger)h\mu^\ddagger + \lambda(1 - \alpha^\dagger - \beta^\dagger)Kl\omega^\ddagger - \delta,$$

the manager's welfare is

$$\begin{aligned} L^{\ddagger}_{CEO} &= (\alpha^{\dagger}+\beta^{\dagger})h\mu^{\ddagger}+\alpha^{\dagger}Kl\omega^{\ddagger}+\delta-\frac{1}{2}(\mu^{\ddagger}+\omega^{\ddagger})^2-\frac{\gamma}{2}\Sigma l^2(\omega^{\ddagger})^2 \\ &\quad -\frac{\gamma}{2}\left[\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)^2/\tau+\frac{(\alpha^{\dagger})^2\tau_s}{(\tau_s+\tau)^2}+(\beta^{\dagger})^2/\tau_{\epsilon}\right], \end{aligned}$$

and the sum is

$$\begin{aligned} L^{\ddagger}_{shareholders}+L^{\ddagger}_{CEO} &= h\mu^{\ddagger}+\lambda(1-\alpha^{\dagger}-\beta^{\dagger})Kl\omega^{\ddagger}-\frac{1}{2}(\mu^{\ddagger}+\omega^{\ddagger})^2-\frac{\gamma}{2}\Sigma l^2(\omega^{\ddagger})^2 \\ &\quad -\frac{\gamma}{2}\left[\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)^2/\tau+\frac{(\alpha^{\dagger})^2\tau_s}{(\tau_s+\tau)^2}+(\beta^{\dagger})^2/\tau_{\epsilon}\right]. \end{aligned} \tag{A3}$$

We can directly compare the aggregate welfare in equations (A2) and (A3):

$$\begin{aligned} M &= L^{\ddagger}_{shareholders}+L^{\ddagger}_{CEO}-(L^{\dagger}_{shareholders}+L^{\dagger}_{CEO}) \\ &= h(\mu^{\ddagger}-\mu^{\dagger})+\lambda(1-\alpha^{\dagger}-\beta^{\dagger})Kl\omega^{\ddagger}-\frac{1}{2}[(\mu^{\ddagger}+\omega^{\ddagger})^2-(\mu^{\dagger})^2]-\frac{\gamma}{2}\Sigma l^2(\omega^{\ddagger})^2. \end{aligned}$$

In the case that $\alpha^{\dagger}Kl > h(1+\gamma\Sigma l^2)\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)$, *i.e.*, the speculative case in Proposition 4, we have $\omega^{\ddagger}=\frac{\alpha^{\dagger}Kl}{1+\gamma\Sigma l^2}$, $\mu^{\ddagger}=0$. It is direct to derive that

$$\begin{aligned} M &= [\alpha^{\dagger}/2+\lambda(1-\alpha^{\dagger}-\beta^{\dagger})]Kl\frac{\alpha^{\dagger}Kl}{1+\gamma\Sigma l^2}-h^2\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)+\frac{1}{2}h^2\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)^2 \\ &> [\alpha^{\dagger}/2+\lambda(1-\alpha^{\dagger}-\beta^{\dagger})]hKl\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)-h^2\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)+\frac{1}{2}h^2\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)^2 \\ &= h\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)\left\{[\alpha^{\dagger}/2+\lambda(1-\alpha^{\dagger}-\beta^{\dagger})]Kl+\frac{h}{2}\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)-h\right\}, \end{aligned}$$

which is positive under the condition that $[\alpha^{\dagger}+2\lambda(1-\alpha^{\dagger}-\beta^{\dagger})]Kl > h\left[2-\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)\right]$.

In the short-termist case given by Proposition 4, it is direct to verify that

$$\omega^{\ddagger}+\mu^{\ddagger}=\mu^{\dagger},$$

and thus,

$$M=\{[\alpha^{\dagger}+\lambda(1-\alpha^{\dagger}-\beta^{\dagger})]Kl-h\}\omega^{\ddagger}-\frac{\gamma}{2}\Sigma l^2(\omega^{\ddagger})^2,$$

which is positive if $\omega^{\ddagger}<\frac{2}{\gamma\Sigma l^2}\{[\alpha^{\dagger}+\lambda(1-\alpha^{\dagger}-\beta^{\dagger})]Kl-h\}$. Since $\omega^{\ddagger}=\frac{\alpha^{\dagger}K}{\gamma\Sigma l}-\frac{h}{\gamma\Sigma l^2}\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)$, we can verify that it holds under the condition that $[\alpha^{\dagger}+2\lambda(1-\alpha^{\dagger}-\beta^{\dagger})]Kl > h\left[2-\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)\right]$.

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