Executive Compensation and Short-Termist Behaviour in Speculative Markets

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We present a multiperiod agency model of stock-based executive compensation in a speculative stock market, where investors have heterogeneous beliefs 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 on the recent corporate crisis than the "rent extraction view" of executive compensation.

1. INTRODUCTION

Following the collapse of the recent technology bubble on NASDAQ and other exchanges, numerous stories have appeared in the financial press pointing out how executives and directors of many companies managed to enrich themselves by selling their shares shortly before their company's stock price crumpled.[1] These striking reports have raised concerns about executive compensation and cast doubt on their intended incentive efficiency.

The classical view of executive compensation as formulated by Mirrlees (1975), Holmstrom (1979), and more recently by Holmstrom and Tirole (1993) among others rests on two fundamental hypotheses. First, CEO incentive schemes efficiently trade off risk sharing and incentive considerations, and second, stock prices are unbiased estimators of firm fundamentals on which CEO pay could be based to reward managerial effort. While the recent corporate crisis has led many commentators to entirely reject this classical view, our paper takes a different perspective. We examine the implications for optimal incentive contracting of relaxing the second hypothesis about stock markets and are thus able to reconcile the incentive perspective of executive compensation with the recent events.

Specifically, in this paper, we depart from Holmstrom and Tirole (1993) by introducing a source for difference of opinions among investors which, in turn, assures that stock prices reflect not only the fundamental value of the firm but also a short-term speculative component. In addition, we postulate that risk-averse managers can take specific actions that boost the speculative

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1. 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 (see *Financial Times*, 31 July 2002).

component in stock prices, albeit at the expense of long-run fundamental value. We solve this modified principal–agent problem and show that optimal compensation contracts will overemphasize short-term stock performance to induce managers to take actions that may increase the speculative component in stock prices. We also consider the role of controlling shareholders who have a longer-term outlook and argue that although they do not benefit directly from stock sales at the inflated short-run prices, they may still encourage some short-termist strategies to reduce their cost of capital.

There is growing evidence that stock prices can deviate from fundamental values for prolonged periods of time.[2] While many economists believe in the long-run efficiency of stock markets, they also recognize that U.S. stock markets have displayed an important speculative component during the period between 1998 and 2000.[3] 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.[4] 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.[5]

The general idea we build on in this paper, that stock prices may be higher than fundamental value when there are differences of opinion and short-sales constraints, actually has a long ancestry in economics and finance. It has been traced back to early writings by Keynes (1936) and later resurfaced in the articles by Miller (1977), Harrison and Kreps (1978) and more recently Morris (1996), Chen, Hong and Stein (2002), and Scheinkman and Xiong (2003).

Several 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 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 that of 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 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 first 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).[6] 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

2. See Shiller (2000) and Shleifer (2000) for supporting arguments and Fama (1998) for a contrarian view.

3. For example, Malkiel (2003).

4. See Cochrane (2002), Lamont and Thaler (2003), and Ofek and Richardson (2003).

5. An extreme example is the trading volume in Palm stock, which turned over once every day according to Lamont and Thaler (2003, table 8).

6. Overconfidence is a frequently observed behavioural bias in psychological studies. See Daniel, Hirshleifer and Teoh (2002) and Barberis and Thaler (2003) for reviews of the related psychological studies and the applications of overconfidence in economics and finance.

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.[7]

Our second departure from Holmstrom and Tirole (1993) is the introduction of a multi-task problem for the CEO, similar to Holmstrom and Milgrom (1992). That is, we allow the CEO to divide his/her time between increasing the long-term value of the firm and encouraging speculation in the stock in the short term by pursuing projects over which investors are likely to have diverging beliefs. In times of great heterogeneity in investor beliefs, 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.[8] Thus, CEOs may be encouraged to pursue short-term speculative projects even at the expense of long-term fundamental value.

Although short-termist behaviour by managers has been highlighted before (most notably, Stein, 1988, 1989; Shleifer and Vishny, 1990; Von Thadden, 1995), 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. In contrast, the managerial short-termism analysed in our paper is consistent with the speculative motive of incumbent shareholders and therefore would not be eliminated even with active shareholder intervention. More closely related to our paper is that of Froot, Perold and Stein (1992), who provide a discussion of the potential link between the short-term horizon of shareholder and short-term managerial behaviour. They point out that the effective horizon of institutional investors, as measured by the frequency of their share turnover, is about 1 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.[9]

Our model, thus, provides a way of reconciling the agency perspective on stock compensation with the recent corporate crisis. We can explain why it is optimal for shareholders to offer compensation contracts under which CEOs can make early gains from a speculative stock price upswing, even though at a later date the firm's market value may collapse. We also provide a rationalization for the observed increase in stock-based compensation during speculative phases. Our theory of executive compensation in speculative markets, therefore, gives an alternative explanation for the recent corporate crisis than the increasingly influential view emphasizing managerial power and abuse brought about by a lack of adequate board supervision (see Bertrand and Mullainathan, 2001; Bebchuk, Fried and Walker, 2002).[10]

Rent-seeking behaviour by managers is always present, but the existing rent-seeking theories fail to explain why rent-seeking behaviour would have trended upwards over the 1990s even

7. In a thought-provoking account of the Internet bubble, 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" (Lewis, 2002).

8. In some cases, these initial shareholders are venture capitalists (VCs), who typically structure the manager's contracts in new firms.

9. Gervais, Heaton and Odean (2003) provide another study of the financial contracting problem in the presence of behavioural biases. They show that rational investors can hire modestly overconfident and optimistic managers to mitigate the agency problem. Our study emphasizes that speculative motive by investors can cause short-termist managerial behaviour through an optimal contract.

10. Murphy (2002) and Jensen and Murphy (2004) propose instead that compensation committees have underestimated the cost of issuing stocks and options to managers.

though corporate governance was generally strengthened over this period. In contrast, our model suggests a link between short-termist behaviour and differences of opinion as measured by share turnover. High turnover is likely to be observed in firms in new industries, where it is usually more difficult to evaluate fundamentals and therefore easier for disagreement among potential investors to arise.

An implication of our analysis is that a failure to maximize long-run firm value is not necessarily a symptom of weak corporate governance, but may be a reflection of a more short-term, speculative orientation of shareholders. Thus, if the goal is to ensure the maximization of long-run fundamental value, then one may want to not only strengthen corporate governance but also lengthen stock-option vesting periods, lengthen director terms, insulate the board of directors more from market swings, and more generally take steps ensuring that controlling shareholders (or the board of directors) have a longer-term outlook. Indeed, we show that the more long-term oriented shareholders are, the less likely they are to encourage the CEO to engage in short-termist behaviour. Having said this, however, we also show that even long-term-oriented shareholders may want to pursue short-termist strategies in particularly speculative stock market environments as a way of reducing the firm's cost of capital.

Our model provides a mechanism for investors' speculative motive to drive firms' overinvestment, as many argued for the investment boom in the telecom industry in the late 1990s. Thus, our study echoes the growing literature on the effects of inefficient stock markets on firms' investment decisions. For example, Morck, Shleifer and Vishny (1990), Blanchard, Rhee and Summers (1993), Stein (1996), Baker, Stein and Wurgler (2003), Polk and Sapienza (2003), Panageas (2004) and Gilchrist, Himmelberg and Huberman (2005) have emphasized that when stocks are overvalued, firms overinvest by taking advantage of a cheap source of capital. As in our model, a link is thus established between equity overvaluation and firm behaviour. However, unlike our paper, this literature does not explain why firms run by managers on behalf of their investors would engage in inefficient investment behaviour that is detrimental to their investors' interests.[11]

In independent work from ours, Jensen (2004) and Jensen and Murphy (2004) have also pointed to what they refer to as *the agency costs of overvalued equity* as the main cause of the recent corporate crisis. They argue that when managers have large holdings of stock or options, they have strong incentives to engage in long-term, value-destroying actions to boost or maintain stock price at inflated levels in the short run. Again, their view lacks a coherent theoretical framework to pit against the efficient markets paradigm. In particular, they do not explain how stock overvaluation arises and how value-destroying managerial actions can temporarily sustain overvalued equity. Our theoretical framework addresses these weaknesses and highlights how both the notions of overvalued equity and the conflict between short-term and long-term value emerge from differences of opinions among shareholders coupled with short-sales constraints.

There is by now a whole body of evidence consistent with at least the weak form of our theory, which shows how for a fixed executive compensation contract, CEO orientation becomes more short-termist in speculative markets (Proposition 4). In particular, there is growing evidence that CEOs have engaged in more value-destroying activities to boost short-term stock price performance, in periods when differences of opinion among investors were more pronounced. We discuss this evidence more systematically in Bolton, Scheinkman and Xiong (2004). It is worth mentioning here one prevalent form of value-destroying activity that has risen

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11. Another related literature deals with the incentive effects of early "exit" by managers or large shareholders (*e.g.* Bolton and von Thadden, 1998; Kahn and Winton, 1998; Maug, 1998; Aghion, Bolton and Tirole, 2000). However, this literature assumes that stock markets are efficient. More recently, Bebchuk and Bar-Gill (2003) have analysed 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.

with stock-option-based compensation throughout the technology bubble: earnings manipulation, either in the form of accounting manipulation (see Peng and Roell, 2003) or in the form of wasteful actions, such as inefficient mergers or delayed investment and R&D expenditure (see Graham, Harvey and Rajgopal, 2005).

One test of the strong form of our theory, which assumes that the contracting parties optimally adapt the compensation contract to market conditions, would be whether the short-term performance weighting in CEO compensation increases with high levels of speculation, as, say, measured by secondary-market trading. This greater short-term weighting may be characterized by shorter vesting periods or shorter CEO tenure, for example. Precise measures of these variables may be difficult to construct, and we are not aware of any study that has attempted to do this.

Interestingly, some policy implications emerging from our analysis echo the arguments supporting the protection of target firms against hostile takeovers by Lipton (1987) and other legal scholars. The central issue in the policy debate on hostile takeovers in the 1980s was whether stock market valuations accurately reflected firms' fundamental value. Most legal scholars and economists were arguing that market values were the best available measure of a firm's long-term value and that any value-increasing takeover, as measured by short-term stock price movements, should go forward. The contrarian view was that many hostile takeovers were purely speculative transactions seeking to realize a quick profit by breaking up undervalued firms in spite of the loss of long-run efficiency that resulted from splitting up the firm. This view has been fighting an up-hill battle because it lacked a coherent theory of asset pricing in speculative markets. A variation of our model, however, can be the basis of a theoretical framework for this view.

The paper proceeds as follows. Section 2 describes the model. Section 3 derives the optimal CEO compensation contract under the classical assumption that stock markets are efficient. In Section 4, we introduce investors with heterogeneous beliefs and characterize the optimal contract in the presence of a speculative market. Section 5 analyses whether a long-term-oriented board can remedy the short-termism generated by a speculative stock market. In Section 6, we discuss some implications from our model. Section 7 concludes the paper. An appendix contains most proofs and numerical illustrations of some comparative statics.

2. 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 spend time or 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 some future investors in the secondary market.[12] 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.[13]

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

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

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

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12. Examples of this type of project can be "making an acquisition or spending a fortune on an Internet venture to satisfy the whims of an irrational market" (see Jensen, 2004).

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

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 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 zero. The unit variance of this project is l^2. This project can be scaled up by the CEO by raising the observable level of managerial time ω devoted to the project. Then, for a given choice of ω, the total variance of the project is $\omega^2 l^2$.

  In summary, the castle-in-the-air venture 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 overvalued 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 time 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 of zero and variance σ_ε^2 (or precision $\tau_\varepsilon = 1/\sigma_\varepsilon^2$).

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

$$E_0 u(W) - \psi(\mu, \omega),$$

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:

$$E_0 u(W) = E_0(W) - \frac{\gamma}{2} \text{Var}_0(W),$$

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 investors. Signal s provides information about u (the value of the firm's fundamental project) and signal θ about z (the per unit return of the castle-in-the-air project). We assume that

$$s = u + \varepsilon_s$$
$$\theta = z + \varepsilon_\theta,$$

where ε_s and ε_θ are again normally distributed random variables with mean of zero 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 investors 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 his/her time optimally between the two tasks and between "work" and "leisure", without exposing him/her to too much risk. As is standard in the theoretical literature on executive compensation, we will only consider linear compensation contracts.[14] Our compensation contracts specify both a short-term and a long-term equity stake for the manager and take the form:[15]

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

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

$$\max_{a,b,c} \; p_0 \quad \text{subject to}$$

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

where $\bar{W}$ is the manager's reservation utility.[16]

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

3. 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 all investors share the same correct belief. 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.

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14. A few recent attempts have been made to explore more general non-linear (option like) contracts (see, *e.g.* Huang and Suarez, 1997; Hemmer, Kim and Verrecchia, 2000).

15. An implicit assumption in our linear specification of the CEO compensation package is that shareholders do not write forcing contracts on the CEO's observable level of managerial activity devoted to the castle-in-the-air project. This is a realistic simplification as in reality a castle-in-the-air project may well involve many dimensions which are difficult to describe accurately and exhaustively in a contract.

16. 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 his/her reservation utility level. But the solution to the dual problem

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

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

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 his/her compensation package to have both short-run and long-run components.

3.1. *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:

$$p_0 = E_0(p_1) \quad \text{and} \quad p_1 = E(e - W \mid s, \theta, \omega),$$

where W is the compensation to the manager.

   The manager's effort choice μ in the fundamental project is not observable. However, in a rational expectations equilibrium, shareholders correctly expect the manager to choose the optimal effort μ^* under the CEO compensation contract and form the following conditional expectations:

$$E(e \mid s, \theta, \omega) = E(u \mid s) + E(v \mid \theta, \omega)$$

$$= h\mu^* + \frac{\tau_s}{\tau + \tau_s}(s - h\mu^*) + \frac{\tau_\theta}{\tau_z + \tau_\theta}\theta\omega \tag{2}$$

$$= h\mu^* + \frac{\tau_s}{\tau + \tau_s}(u - h\mu^* + \varepsilon_s) + \frac{1}{\eta + 1}\theta\omega. \tag{3}$$

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 $\tau_z/\tau_\theta = \eta$ and $s = u + \varepsilon_s$.

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

$$p_1 = E(e - W \mid s, \theta, \omega) = E[e - (ap_1 + be + c) \mid s, \theta, \omega].$$

Or, solving for p_1,

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

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 equation (1) defining the manager's compensation, we obtain

$$W = \alpha E(e \mid s, \theta, \omega) + \beta e + \delta,$$

with α, β, and δ given by

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

   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 CEOs 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 $\alpha + \beta \leq 1$.

3.2. *The manager's optimization problem*

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

$$\max_{\mu,\omega} \mathrm{E}_0[\alpha \mathrm{E}(e \mid s, \theta, \omega) + \beta e] - \frac{1}{2}(\mu + \omega)^2 - \frac{\gamma}{2}\mathrm{Var}_0[\alpha \mathrm{E}(e \mid s, \theta, \omega) + \beta e],$$

where $\mathrm{E}_0()$ and $\mathrm{Var}_0()$ are unconditional expectation and variance of the manager at $t = 0$.

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 informationally efficient market, it never pays to set $\omega > 0$. A higher ω only increases the variance of the manager's pay-off and involves a higher effort cost. Thus, in an informationally efficient stock market, the CEO would not engage in any short-termist behaviour.[17]

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

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

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 ω and μ^* in (3), we obtain the unconditional expected firm value at $t = 0$:

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

where μ^* is the effort choice of the CEO, as given in equation (5).

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

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

where

$$\mathrm{Var}_0[\alpha \mathrm{E}(e \mid s, \theta) + \beta e] = \mathrm{Var}_0\left[\left(\frac{\tau_s}{\tau + \tau_s}\alpha + \beta\right)(u - h\mu^*(\alpha, \beta)) + \frac{\tau_s}{\tau + \tau_s}\alpha\varepsilon_s + \beta\varepsilon\right]$$

$$= \frac{1}{\tau}\left(\frac{\tau_s}{\tau + \tau_s}\alpha + \beta\right)^2 + \frac{\alpha^2\tau_s}{(\tau + \tau_s)^2} + \frac{\beta^2}{\tau_\varepsilon}. \tag{7}$$

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17. This result contrasts with those of Stein (1989) and Von Thadden (1995), where short-termist behaviour can take place in an efficient stock market for "signal jamming" reasons.

3.3. *The shareholder's optimization problem*

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

$$\max_{\alpha,\beta} \; p_0 = \max_{\{\alpha,\beta\}} \; \mathrm{E}_0[e - W]$$

$$= \max_{\{\alpha,\beta\}} \left\{ h\mu - \bar{W} - \frac{1}{2}\mu^2 - \frac{\gamma}{2}\left[\frac{1}{\tau}\left(\frac{\tau_s}{\tau+\tau_s}\alpha+\beta\right)^2 + \frac{\alpha^2\tau_s}{(\tau+\tau_s)^2} + \frac{\beta^2}{\tau_\varepsilon}\right]\right\}. \quad (8)$$

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

$$\min_{\{\alpha,\beta\}} \; \frac{\gamma}{2}\left[\frac{1}{\tau}\left(\frac{\tau_s}{\tau+\tau_s}\alpha+\beta\right)^2 + \frac{\alpha^2\tau_s}{(\tau+\tau_s)^2} + \frac{\beta^2}{\tau_\varepsilon}\right],$$

$$\text{subject to} \; h\cdot\left(\frac{\tau_s}{\tau+\tau_s}\alpha+\beta\right) = \mu. \quad (9)$$

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 $\gamma > \frac{h^2\tau^2}{\tau+\tau_s+\tau_\varepsilon}$, the optimal level of effort is given by*

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

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

$$\begin{cases} \alpha^\dagger = \frac{(\tau_s+\tau)h^2}{(\tau_s+\tau_\varepsilon)\left[h^2+\gamma\left(\frac{1}{\tau}+\frac{1}{\tau_s+\tau_\varepsilon}\right)\right]} \\[2mm] \beta^\dagger = \frac{\tau_\varepsilon h^2}{(\tau_s+\tau_\varepsilon)\left[h^2+\gamma\left(\frac{1}{\tau}+\frac{1}{\tau_s+\tau_\varepsilon}\right)\right]}. \end{cases}$$

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

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

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

$$\begin{cases} \alpha^\dagger = \frac{\gamma\,(\tau+\tau_s)(\tau+\tau_s+\tau_\varepsilon)}{h^2\tau^2\tau_\varepsilon+\gamma\,(\tau+\tau_s)(\tau+\tau_s+\tau_\varepsilon)} \\[2mm] \beta^\dagger = \frac{h^2\tau^2\tau_\varepsilon}{h^2\tau^2\tau_\varepsilon+\gamma\,(\tau+\tau_s)(\tau+\tau_s+\tau_\varepsilon)}. \end{cases}$$

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

    Proof. See Appendix A. ‖

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 him/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 he/she is risk neutral. Here, when the manager is close to being risk neutral, it may be optimal to have him/her "own" the entire firm at time zero. However, for diversification reasons, the manager will want to sell part of his/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.

4. OPTIMAL CEO COMPENSATION IN A SPECULATIVE MARKET

A critical assumption in existing models of executive compensation is that stock markets are informationally 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 analyse 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).[18]

More specifically, their model of speculative secondary stock markets involves trading between overconfident investors, who may disagree about the value of the firm. The introduction of investors with heterogeneous beliefs 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 differ in their estimates of the informativeness of the signal θ, which in turn leads to differences in their beliefs at $t = 1$ about the firm's terminal value, even if all investors start with the same prior beliefs at $t = 0$. If $\theta > 0$ ($\theta < 0$), investors who overestimate the precision of θ will buy (sell) shares from other investors who are either rational or less overconfident with respect to that signal. 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, 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 $t = 1$.

A particularly telling example of such a castle-in-the-air project is Enron's venture into broadband video on demand. This venture, along with the partnership with Blockbuster video, was valued at several billion dollars, while Enron was still perceived as a model company: according to the *New York Times* (17 January 2002) "The start of the broadband division helped send the stock leaping still further from \$40 in January [2001] to \$90 several months later, when

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18. There are a number of other behavioural models of stock markets, such as those of De Long, Shleifer, Summers and Waldmann (1990), Barberis, Shleifer and Vishny (1998), Daniel, Hirshleifer and Subrahmanyam (1998), and Hong and Stein (1999) that we could have used. We have opted for the approach of Scheinkman and Xiong (2003) because they explicitly model the non-fundamental component in prices and the endogenous short-term horizon of investors as resulting from speculative trading by overconfident investors.

Enron announced a 20-year partnership with Blockbuster Entertainment to provide video-on-demand services for consumers and subsequently announced a high-speed Internet deal with the Microsoft Network". In addition, the same *New York Times* article mentions that a spokesman for the company said that Enron hoped to capitalize on the dot-com frenzy for online entertainment stocks, "at the time, people were actually raising capital on weird concepts".[19]

4.1. *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 disagreements on the informativeness of signal θ. Specifically, we assume that group-A investors treat the precision of the signal as $\phi^A \tau_\theta$, and group-B investors treat it 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 homogeneous beliefs. What is crucial for our analysis is the difference between ϕ^A and ϕ^B, which we assume each group is fully aware of. This disagreement is consistent with the notion of overconfidence that several recent finance models have built on to explain investor overreaction and excessive trading.[20] For the sake of consistency with this overconfidence interpretation, we shall also assume that $\phi^A > 1$ and/or $\phi^B > 1$.

To simplify the contracting problem at $t = 0$, we shall assume that all controlling shareholders and the CEO are of the same group, say, group A, and group-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 heterogeneous beliefs. But also, it allows us to avoid modelling 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.[21]

For simplicity, we confine investors' disagreement to just the precision of signal θ. Investors make the same observation of the scale of the castle-in-the-air project ω and 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 $t = 1$:

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

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:

$$\hat{v}^A = \mathrm{E}^A(v \mid \theta, \omega) = \frac{\phi^A \tau_\theta}{\tau_z + \phi^A \tau_\theta}\theta\omega = \frac{\phi^A}{\eta + \phi^A}\theta\omega,$$

$$\hat{v}^B = \mathrm{E}^B(v \mid \theta, \omega) = \frac{\phi^B \tau_\theta}{\tau_z + \phi^B \tau_\theta}\theta\omega = \frac{\phi^B}{\eta + \phi^B}\theta\omega.$$

19. Interestingly, even though Enron is now mainly remembered as a case of flagrant fraud, it clearly is also an example of a firm aggressively playing into the stock market bubble.

20. See, for example, Daniel *et al.* (1998), Odean (1998), and Scheinkman and Xiong (2003).

21. The assumption that the CEO and shareholders belong to the same group is purely for technical convenience. Our main results would still hold if, say, the CEO belongs to a third group. However, under such an assumption, additional considerations arise at $t = 0$ if, say, a more optimistic CEO contracts with more sceptical shareholders. In such a situation, it is likely that the optimal incentive scheme would be even more short-term oriented, as shareholders may then benefit from rewarding the CEO with what in their eyes is overvalued stock.

Thus, the difference in posterior beliefs is

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

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 investors with heterogeneous beliefs. 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.[22]

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. The short-sales constraints prevent rational arbitrageurs from eliminating the upward-biased price set by optimistic investors. In practice, there are many other constraints that restrict arbitrage trading even in absence of explicit short-sales constraints (see Shleifer and Vishny, 1997). 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

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

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

$$V_0 = E_0^A[V_1] = h\mu + E_0^A[\max(\hat{v}^B - \hat{v}^A, 0)].$$

That is, the value of the firm at $t = 0$ now also includes the value of the option to sell to group-B investors, $E_0^A[\max(\hat{v}^B - \hat{v}^A, 0)]$.

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:[23]

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

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

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

We have thus established that the value of the firm at $t = 0$ satisfies:

22. 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, for example, D'Avolio (2002), Geczy, Musto and Reed (2002), and Jones and Lamont (2002), have documented that it is costly to short sell stocks, especially for overvalued tech stocks in the recent "bubble" period.

23. 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 overestimate the precision of θ themselves and believe that ε_θ only has a variance of $\eta l^2/\phi^A$

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

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

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 $\phi^A - \phi^B$ is approaching zero, the stock price is independent of ω, as before. In other words, in the presence of heterogeneous beliefs among 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 $t = 1$.[24] The parameter K measures the extent to which investors' beliefs might differ at $t = 1$, and can be referred to as the *speculative coefficient*. As can be seen from Proposition 2, this coefficient K is affected both by the difference in ϕ^A and ϕ^B 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.

4.2. *The CEO's problem*

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

$$p_1 = \max\{E_1^A[e - (ap_1 + be + c)], E_1^B[e - (ap_1 + be + c)]\}$$

or

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

Making the same change of variables as before

$$\alpha = \frac{a}{1 + a}(1 - b), \quad \beta = b, \quad \delta = \frac{c}{1 + a} \tag{13}$$

we then have

$$p_1 = (1 - \alpha - \beta)(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}) - \delta \tag{14}$$

and

$$p_0 = (1 - \alpha - \beta)E_0^A[\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}] - \delta. \tag{15}$$

Given a contract $\{\alpha, \beta, \delta\}$, the manager then chooses his/her best actions by solving[25]

$$\max_{\mu, \omega} E_0^A[\alpha(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}) + \beta e + \delta] - \frac{1}{2}(\mu + \omega)^2 - \frac{\gamma}{2}\text{Var}_0^A[\alpha(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}) + \beta e]. \tag{16}$$

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24. Note that if investors also had disagreement on the precision of signal s, then the speculative option value would be attached to the long-run venture u as well. Heterogeneous beliefs and speculative markets would then give rise to another inefficiency: overinvestment in u.

25. As the CEO is risk averse, he/she will always sell all his/her non-vested shares at $t = 1$.

Initial shareholders, thus, choose $\{\alpha, \beta\}$ to maximize the firm's net expected value subject to the manager's incentive constraint in equation (16) and his/her participation constraint. Substituting for $\hat{u}$, $\hat{v}^A$, and $\hat{v}^B$ into equation (14), we obtain the following expression for equilibrium share price at $t = 1$:

$$p_1 = (1 - \alpha - \beta) \left[h\mu^* + \frac{\tau_s}{\tau_s + \tau}(s - h\mu^*) \right]$$

$$+ (1 - \alpha - \beta)\omega \max \left(\frac{\phi^A \theta}{\eta + \phi^A}, \frac{\phi^B \theta}{\eta + \phi^B} \right) - \delta.$$

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.

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

$$\Sigma = \frac{1}{2} \left[\left(\frac{\alpha \phi^A}{\eta + \phi^A} + \beta \right)^2 + \left(\frac{\alpha \phi^B}{\eta + \phi^B} + \beta \right)^2 + \frac{\eta \alpha^2}{\phi^A} \left(\frac{\phi^{A2}}{(\eta + \phi^A)^2} + \frac{\phi^{B2}}{(\eta + \phi^B)^2} \right) \right.$$

$$\left. - \frac{(\eta + \phi^A)\alpha^2}{\pi \phi^A} \left(\frac{\phi^A}{\eta + \phi^A} - \frac{\phi^B}{\eta + \phi^B} \right)^2 \right]. \tag{17}$$

Proof. See Appendix A. ‖

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 investors' estimates of the signal precision. In other words, it is immediately apparent from this expression that the return to scaling up the speculative project is increasing in the heterogeneous beliefs 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:

$$\omega = \frac{\alpha K}{\gamma \Sigma l} - \frac{h}{\gamma \Sigma l^2}\left(\frac{\alpha \tau_s}{\tau_s + \tau} + \beta\right) > 0 \quad and$$

$$\mu = h\left(1 + \frac{1}{\gamma \Sigma l^2}\right)\left(\frac{\alpha \tau_s}{\tau_s + \tau} + \beta\right) - \frac{\alpha K}{\gamma \Sigma l} \geq 0$$

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

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

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

Proof. See Appendix A. ‖

Because he/she is averse to risk, the CEO faces a lower marginal cost of effort on μ than on ω. More explicitly, his/her marginal cost of action μ is only $(\mu + \omega)$, while marginal cost on ω is $[(\mu + \omega) + \gamma \Sigma l^2 \omega]$. Therefore, it only pays the manager to engage in short-termist behaviour (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 $K l < \frac{h \tau_s}{\tau_s + \tau}$, which holds when K or l is 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 $\left(\text{say, } K l > \frac{h \tau_s}{\tau_s + \tau}\right)$, the CEO would want to pursue such a short-termist strategy provided that his/her short-term stock holdings α is sufficiently large relative to 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.

4.3. *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:

$$\max_{\{\alpha, \beta, \delta\}} p_0 = \max_{\{\alpha, \beta, \delta\}} (1 - \alpha - \beta)(h\mu + K l \omega) - \delta \tag{18}$$

subject to

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

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

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

$$-\frac{\gamma}{2}\left[\frac{1}{\tau}\left(\frac{\alpha\tau_s}{\tau_s+\tau}+\beta\right)^2 + \frac{\alpha^2\tau_s}{(\tau_s+\tau)^2} + \frac{\beta^2}{\tau_\varepsilon}\right] - \bar{W}, \tag{19}$$

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 non-linearity 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 (19) 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 behaviour 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 behaviour, 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 A.   ‖

Thus, in accordance with standard agency theory, when the manager is risk neutral, it is optimal to make him/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 potential heterogeneous beliefs 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 him/her to sell all his/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 $t = 1$. Since the manager owns the firm, the contract can be interpreted as a commitment device.

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

4.4. *Risk-averse CEO*

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 the speculative coefficient K
under which the manager engages in short-termist behaviour, $\omega \neq 0$. We give a sufficient condi-
tion 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 CEO may engage in short-termist behaviour
(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 his/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:

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

Note that if $\phi^B = 1$, 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 less sophisticated traders (group-B investors) affect the firm
and the managerial contract? Although the firm could always choose to ignore these investors in
the market, Proposition 7 below provides a sufficient condition on the speculative coefficient K
under which shareholders optimally adopt a managerial contract that induces some short-termist
behaviour 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 speculative coefficient K is sufficiently large that*

$$Kl > h, \quad and \quad \left(Kl - \frac{h\tau_s}{\tau_s + \tau} \right) \alpha^\dagger > h\beta^\dagger, \tag{20}$$

then the optimal managerial contract (α, β, δ) induces short-termist behaviour: $\omega > 0$.

Proof.   See Appendix A.   ‖

The contract $(\alpha^\dagger, \beta^\dagger, \delta^\dagger)$ is the optimal contract in the absence of heterogeneous beliefs, and
the total benefit that the CEO and the initial shareholders derive from this contract represents the
maximum if no short-termist behaviour is pursued. When the risk-averse CEO 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. Thus, both the initial shareholders and the CEO are better off
with some short-termist behaviour in the presence of group-B investors.

A complete analytical characterization of the optimal contract is not available due to
complexity involved in the constrained optimization of both investors and managers. This is
not surprising, as simple comparative statics results in contracting problems with moral hazard
are usually not available. Instead, we provide a comprehensive set of numerical examples in
Appendix B to illustrate how the optimal contract and managerial actions vary with model para-
meters such as risk aversion of the CEO, the overconfidence level of group-B investors, returns on
long-term and short-term effort, and fundamental risk. Although the optimal contracting problem
in the presence of speculative markets does not yield simple and monotonic comparative statics
results, as apparent from the numerical solutions, the bottom line is clear that a compensation

contract that motivates short-termist managerial behaviour will be used when the stock market becomes sufficiently speculative. For a more modest level of market speculation, short-termist behaviour will still arise in the equilibrium if the CEO is more risk tolerant, or when the expected return to the firm's long-term project is sufficiently low and the uncertainty is high.

5. DOES A LONG-TERM-ORIENTED BOARD REMEDY SHORT-TERMISM?

Our analysis has highlighted how shareholders may want to induce managerial short-termism as a way of increasing the value of the option to resell to more optimistic shareholders at $t = 1$. A natural question then arises whether long-term-oriented shareholders could remedy this short-termism in firms.

We shall argue in this section that even long-term-oriented boards may want to exploit speculative episodes in stock markets. The main reason is that during such episodes the cost of capital is below the firm's long-run value, so that incumbent shareholders benefit by raising capital[26] (see Stein, 1996; Baker *et al.*, 2003).

While it is straightforward to see that equity raised at $t = 0$ is more undervalued relative to long-run value, e, the higher is the speculative option value, it is less clear how the firm will use the additional funds raised from the market. These funds could be used to raise dividend pay outs or for investment. During the technology bubble, for example, most of the funds raised by telecommunication firms were spent in additional investments. In our model, however, the scale of the firm is fixed. Thus, to keep the model as simple as possible, we shall only allow the firm to use the new funds raised from equity markets to make higher dividend payments.

Specifically, we modify our model in this section to allow for equity issuance at $t = 1$. We shall assume that incumbent shareholders own one share at $t = 0$, and may choose to issue an additional $q - 1$ shares at $t = 1$, bringing the total number of shares to q, $(q \geq 1)$. For simplicity, we treat q as an exogenous parameter. The proceeds from this issue are then paid out as dividends to incumbent shareholders. This simple extension of our model captures in a stark way how even buy-and-hold investors may benefit from exploiting speculative episodes.

Should the firm choose to issue new shares, then the stock price at $t = 1$ will be given by

$$p_1 = \frac{1}{q} \max\{E_1^A(e - W),\ E_1^B(e - W)\}. \tag{21}$$

By substituting in the executive compensation cost $W = ap_1 + be + c$, we further obtain

$$p_1 = \frac{1 - b}{q + a} \max\{E_1^A(e),\ E_1^B(e)\} - \frac{c}{q + a}.$$

Making a similar change of variables as in (13) while also adjusting for the share issuance, we define

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

Using this notation, the total compensation to the manager becomes

$$W = ap_1 + be + c$$
$$= \alpha \max\{E_1^A(e),\ E_1^B(e)\} + \beta e + \delta,$$

which is the same as before.

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26. We thank an anonymous referee for this insight.

The value of a share at $t = 0$ to a buy-and-hold investor, who commits to hold his shares to the final liquidation, is then

$$p_0 = \frac{1}{q} E_0^A (e - W) + (q - 1) E_0(p_1),$$

where the first term represents the liquidation value of holding the share to $t = 2$, and the second term represents the dividend obtained from issuing an additional $(q - 1)$ shares. Substituting in p_1 from equation (21), we further obtain

$$p_0 = \frac{1}{q} E_0^A (e - W) + \frac{q - 1}{q} E_0^A [\max\{E_1^A (e - W), \ E_1^B (e - W)\}].$$

Thus, the value of shares for a buy-and-hold investor will also depend on the short-term resale option that we discussed in the earlier sections. We define

$$\lambda \equiv \frac{1}{q} \in [0, 1].$$

Then, the long-term investor's objective function can be written as a weighted average of the long-term value and the short-term price:

$$\max_{\{\alpha, \beta, \delta\}} \ \lambda E_0^A (e - W) + (1 - \lambda) E_0^A [\max\{E_1^A (e - W), \ E_1^B (e - W)\}], \qquad (22)$$

where the weight on the short-term price $1 - \lambda = \frac{q-1}{q}$ increases with $q - 1$, the number of shares to be issued at $t = 1$. The next proposition provides a sufficient condition under which the manager engages in short-termist behaviour even when initial shareholders commit to hold their shares to the final liquidation.

Proposition 8. *Let $(\alpha^\dagger, \beta^\dagger, \delta^\dagger)$ be the optimal contract given an efficient market, as specified in Proposition 1. If the speculative coefficient K and the number of shares to be issued $q - 1$ are sufficiently large such that*

$$\alpha^\dagger K l > h, \quad and \quad [2(1 - \lambda)(1 - \beta^\dagger) - \alpha^\dagger] K l > h \left[2 - \left(\frac{\alpha^\dagger \tau_s}{\tau_s + \tau} + \beta^\dagger \right) \right], \qquad (23)$$

then the resulting optimal managerial contract (α, β, δ) chosen by a long-term-oriented board would still generate some short-termist behaviour: $\omega > 0$.

Proof. See Appendix A.   ‖

Proposition 8 shows that in a speculative market, even a long-term-oriented board, which represents shareholders who commit to hold their shares for the long term, might want to adopt a managerial contract to motivate some short-termist effort from the manager. Admittedly, it takes a larger speculative coefficient K before a short-termist behaviour becomes attractive. The numerical results reported in Appendix B further illustrate that the more shares the firm can issue 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.[27]

27. Although our model assumes that the manager is rational, we also note that stock-based compensation could provide a cheaper way to compensate the manager if he/she is overly optimistic about the firm's prospects. In fact, Bergman and Jenter (2003) provide evidence that firms grant more equity-based compensation to executives and employees in lower ranks when they hold exuberant sentiments about the future prospect of their firm. In such a case, reducing compensation cost provides another argument for a long-term board to use equity-based compensation even if it induces short-termist behaviour.

The analysis in this section, thus, 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. However, such a move can only partially reduce short-termism.

6. DISCUSSION

6.1. *Governance failure vs. speculative markets*

Our analysis has implications for corporate governance and the regulation of CEO stock-option plans. Reacting to the recent corporate scandals, many commentators (most notably, Bebchuk *et al.*, 2002) have argued that the current structure of CEO pay in the U.S. cannot be rationalized on the basis of agency theory. These commentators argue that the main problem with CEO compensation in the U.S. is a failure of corporate governance and call for a regulatory response to strengthen boards of directors, as well as audit and remuneration committees. Bertrand and Mullainathan (2001) propose a similar skimming view of CEO pay, in which CEOs capture the pay-setting process, and analyse the hypothesis that firms with weaker governance tend to grant more pay for luck. They find some corroborating evidence in the oil industry.

Although the rent extraction and skimming view is consistent with the trend of quickly growing executive compensation in the 1990s, it does not square well with other trends over the 1990s towards greater board independence, a higher proportion of externally recruited CEOs, a decrease in the average tenure of CEOs, and higher forced CEO turnover, as Hermalin (2005) has pointed out. Our view is that to reconcile all these trends, the missing link lies in the booming stock markets over the 1990s, which ended with a spectacular bubble in high-tech stocks.

Our model highlights the tension between current shareholders and future investors. When it is possible for future investors to overvalue the firm due to their optimism, it is in the interest of current shareholders to cater to such potential sentiment even at the expense of firm long-term fundamental value. If, as we propose, the explanation for the corporate failures is related to speculative stock markets, and if the recent CEO compensation excesses are a by-product of the technology bubble, then different policy implications would emerge. Thus, for example, further strengthening of boards may not make a major difference. On the other hand, regulatory limits on CEOs' or controlling shareholders' ability to unwind their own stock holdings early (whether desirable or not) would provide a more effective deterrent to the pursuit of short-term strategies.

The performance of projects backed by VCs provides a natural experiment to isolate the effects of speculative markets from that of governance failures. VCs are active monitors of the firms that they finance, directly involved in project selection and managerial compensation. Therefore, it is difficult to argue that there could be any governance failure in VC-financed firms. It is also important to recognize that VCs' horizon is usually no longer than the firm's initial public offering (IPO). In this sense, VCs' objective is to maximize the market value of their ventures at the time of the IPO, rather than the long-run value of firms.

Hendershott (2003) provides an analysis of the performance of 435 venture-backed dot-com firms during the Internet boom. According to his study, VCs dramatically increased their investment in Internet projects in 1997 and 1998, and they successfully sold about half of them through either public offerings or direct sales at more than three times their initial investment. However, the longer term performance of these projects has been dreadful—the annualized returns by the end of 2000 were −42% and −52% for the projects financed initially in 1997 and 1998, and only 10% of these can be counted as long-term successes (worth at least 1·5 times the initial investment). Overall, the dismal performance of VC-backed Internet projects during the latter period of the Internet boom provides a vivid example of firms pursuing value-destructive projects in response to a speculative market.

In general, the rent extraction view and our speculative market explanation provide distinct implications on when firms are likely to do poorly. While the rent extraction view implies that corporate failures are more likely to occur in firms with weak governance structures, irrespective of market conditions, our view points in a different direction. We expect short-termist behaviour to lead to corporate failures following speculative episodes, irrespective of whether firms have good or bad governance. In particular, we expect failures to be more likely in new industries where it is harder to evaluate the fundamental profitability of a firm and consequently where there is more 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.

6.2. *Empirical implications*

Our model establishes a direct link between the investment horizons of shareholders and the CEO. In a speculative stock market, incumbent shareholders have a shorter horizon and align the manager's horizon to theirs by weighing the CEO's compensation more heavily on short-term stock price performance. Our analysis, thus, echoes the observation by Froot *et al.* (1992) that the average 1-year holding period of institutional investors in stocks might be too short for them to exercise long-term discipline on firms.

In practice, a significant fraction of shares are held by institutions. To the extent that institutions have a say in the design of executive compensation contracts, our model would predict a positive correlation between institutional shareholder turnover and the firm manager's short-termist behaviour. Interestingly, Bushee (1998) finds supporting evidence of such a relation. He shows that managers in firms where a large proportion of institutional owners have a high portfolio turnover tend to reduce R&D expenses to boost short-term earnings.

To draw further empirical implications of our analysis, it is helpful to distinguish between a weak and a strong form of our theory, based on the awareness of the contracting parties of the existence of a speculative bubble. Under the weak form, the contracting parties design the executive compensation contract based on the assumption that markets are efficient, as we analyse in Section 4. Given such a contract, the CEO will still choose to pursue a short-term strategy when a bubble actually arises, as in Proposition 4. Earnings manipulation by firms is a clear example of short-termist behaviour. Several recent empirical studies, for example, Bergstresser and Philippon (2002) and Peng and Roell (2003), report the link between earnings manipulation and stock-based compensation to firm executives and find supporting evidence that stock-based compensation provides incentives for executives to manipulate earnings.

The strong form of our theory is that the contracting parties are aware at least partially about possible market speculation and design managerial compensation contracts partly to induce CEOs to exploit future investors. More specifically, the strong form would imply that, as the market becomes more speculative, the compensation contract puts more weight on short-term stock price performance (a shorter vesting period). There have been few if any empirical studies that have explicitly focused on variations of investing periods.

There is some evidence confirming the importance of the conflict between current and future shareholders. Teoh, Welch and Wong (1998) show that many firms engage in earnings manipulation right before their IPOs. They use abnormal discretionary accruals as a measure of earnings manipulation and show that firms in the most aggressive earnings management quartiles underperform compared with those in the least aggressive quartiles by 20% in the 3 years following the IPO. It is easy to understand the incentive of firm owners or shareholders of firms before the IPOs, that is to sell the firm for a higher price. The effectiveness of earnings manipulation in boosting IPO prices and the widespread use of such practices clearly supports our view that current shareholders did engage in short-term strategies that aim to exploit future investors.

The recent survey by Graham *et al.* (2005) of over 400 financial executives on their decisions relating to financial reporting provides further support for our analysis. They find that executives put great emphasis on meeting or beating short-term earnings benchmarks or forecasts, since earnings announcements critically affect the stock price. To this end, 80% of respondents report that they would be prepared to decrease discretionary spending on R&D, advertising, and maintenance to meet earnings targets. More disconcertingly, more than half the respondents state that they would be willing to burn "real" cash flows by, say, delaying new projects and capital expenditures for the sake of reporting expected accounting numbers. Some participants even explicitly point out in interviews that there is a constant tension between short-term and long-term objectives of firms. These survey results again are consistent with our theory that firm executives are spurred by speculation in stock markets to take on short-term actions, such as earnings manipulation and delaying profitable real investments, to boost short-term stock prices.[28]

6.3. *Equity overvaluation and value-destroying investments*

The tension between current and future shareholders can cause great damage to firms especially if it gives rise to overinvestment in a bubble market. Jensen (2004) and Jensen and Murphy (2004) also emphasize the risk of overinvestment when equity is overvalued. Without pointing to a specific mechanism, Jensen (2004) remarks:

> the recent dramatic increase in corporate scandals and value destruction is due to what I call the agency costs of overvalued equity. I believe these costs have amounted to hundreds of billions of dollars in recent years. When a firm's equity becomes substantially overvalued it sets in motion a set of organizational forces that are extremely difficult to manage, forces that almost inevitably lead to destruction of part or all of the core value of the firm.

Our model provides a mechanism through which speculative stock markets lead firms to overinvest in inefficient projects. Our mechanism is consistent with several recent empirical studies on this issue. In particular, Polk and Sapienza (2003) find a positive relation between firms' overinvestment and a number of proxies for mispricing of their stocks, such as discretionary accruals and price momentum. They also show that investment is more sensitive to mispricing proxies for firms with higher R&D intensity and share turnover. Both variables, as shown in our model, are positively related to speculative prices. Gilchrist *et al.* (2005) also find that firms' investment increases with the variance of analysts' earnings forecasts, a proxy for the dispersion of investor beliefs—the crucial force that drives speculative prices in our model.

Jensen and Murphy (2004) argue that financial markets cannot easily correct this overvaluation problem. While the market for corporate control could solve many of the problems of undervalued equity in the 1970s and 1980s through hostile takeovers, leveraged buy-outs, and management buy-outs, it could not solve the problem associated with equity overvaluation, as no one can expect to make a profit by buying an overvalued firm and then eliminating the overvaluation.[29]

To resolve the agency cost associated with overvalued equity, our model suggests that it is helpful to have a long-term-oriented board, which will be less inclined to approve a

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28. Of course, other theories of short-termism based on asymmetric information and signal jamming (Stein, 1989; Von Thadden, 1995) can also explain why managers would engage in earnings manipulation, but they would have greater difficulty explaining how such manipulation generates short-term price hikes and why manipulation should vary positively with secondary-market trading.

29. The market could in theory solve this overvaluation problem if investors were more willing and able to short overvalued stocks. But there are fundamental reasons why many individual investors and institutions such as mutual funds and pension funds do not short stocks. One obvious reason being that a short position may involve unbounded losses. It is, however, possible to intervene at the margin and make shorting somewhat easier, by, for example, eliminating the *uptick rule* (an SEC rule stating that a short sale can only be executed on an "uptick" or a zero plus tick).

compensation package that encourages short-termist strategies. Conceivably, an even more effective policy intervention might be to impose restrictions on minimum vesting periods of executives' stock holdings. Such a policy could significantly weaken a simple instrument that speculative shareholders can currently use.

Our model also lends support to policy proposal that calls for more monitoring by the board and audit committees of firms' reporting policies. Better disclosure from a firm can make it less likely that differences in investors' beliefs arise. This is analogous to decreasing the value of parameter l, which, as we show in Appendix B, makes the equilibrium less speculative and therefore managers less likely to pursue short-termist strategies.

7. CONCLUSION

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 heterogeneous beliefs by investors 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. In contrast to the short-termism analysed in the previous literature, this type of managerial short-termism is directly driven by the speculative motive of firms' controlling shareholders. It is a form of endogenous short-termism driven by differences of opinion. Our theory provides a perspective for the recent corporate crisis which is different from that of the popular "rent extraction view" of executive compensation. Where the rent extraction view calls for a wholesale strengthening of boards, our model instead calls for a more specific intervention in the direction of a more long-term orientation of boards.

APPENDIX A. SOME PROOFS

Proof to Proposition 1.

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

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

subject to the constraint that

$$0 \leq \beta \leq 1, \ 0 \leq \alpha \leq (1 - \beta).$$

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

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

Otherwise, if $x \geq \frac{\tau_s + \tau_\varepsilon}{\tau + \tau_s + \tau_\varepsilon}$, the constraint $\alpha + \beta \leq 1$ is binding and the optimal combination is

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

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

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

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

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

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

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

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

and its maximum is reached at

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

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

Proof to Lemma 3.

The manager's expected monetary compensation is

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

And the variance of the manager's pay-off is

$$\begin{aligned} &\mathrm{Var}_0^A[\alpha(\hat{u} + \max\{\hat{v}^A, \hat{v}^B\}) + \beta e + \delta] \\ &= \mathrm{Var}_0^A \left[\alpha \frac{\tau_s}{\tau_s + \tau}(s - h\mu^*) + \alpha \omega \max \left\{ \frac{\phi^A \theta}{\eta + \phi^A}, \frac{\phi^B \theta}{\eta + \phi^B} \right\} + \beta e \right] \\ &= \mathrm{Var}_0^A \left[\frac{\alpha \tau_s (u + \varepsilon_s)}{\tau_s + \tau} + \beta(u + \varepsilon) \right] + \omega^2 \mathrm{Var}_0^A \left[\alpha \max \left\{ \frac{\phi^A}{\eta + \phi^A}(z + \varepsilon_\theta), \frac{\phi^B}{\eta + \phi^B}(z + \varepsilon_\theta) \right\} + \beta z \right] \\ &= \left(\frac{\alpha \tau_s}{\tau_s + \tau} + \beta \right)^2 \sigma^2 + \frac{\alpha^2 \tau_s^2}{(\tau_s + \tau)^2} \sigma_s^2 + \beta^2 \sigma_\varepsilon^2 + \Sigma l^2 \omega^2, \end{aligned}$$

where Σ is given in equation (17). 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

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

where a_1 and a_2 are two positive constants.

Proof.   Through direct integration, we have

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

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

$$E\{\max[a_1(x+y), a_2(x+y)] + bx\}^2$$

$$= \int_{-\infty}^{\infty} dy \frac{1}{\sqrt{2\pi}\sigma_y} e^{-y^2/2\sigma_y^2} \left\{ \int_{-\infty}^{-y} dx \frac{1}{\sqrt{2\pi}\sigma_x} e^{-x^2/2\sigma_x^2} [(a_1+b)x + a_1 y]^2 \right.$$

$$\left. + \int_{-y}^{\infty} dx \frac{1}{\sqrt{2\pi}\sigma_x} e^{-x^2/2\sigma_x^2} [(a_2+b)x + a_2 y]^2 \right\}$$

$$= \frac{1}{2} [(a_1+b)^2 + (a_2+b)^2]\sigma_x^2 + \frac{1}{2}(a_1^2 + a_2^2)\sigma_y^2$$

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

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

Using the previous two equations, we can calculate the variance as given in equation (A.1).   ‖

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 the 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

$$\frac{\partial L}{\partial \mu} = \left(\frac{\alpha\tau_s}{\tau_s + \tau} + \beta \right) h - (\mu+\omega) + \lambda_1 = 0$$

$$\frac{\partial L}{\partial \omega} = \alpha Kl - (\mu+\omega) - \gamma \Sigma l^2\omega + \lambda_2 = 0.$$

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

Proof to Proposition 6.
    For a risk-neutral manager, his/her optimal actions for a given contract $\{\alpha, \beta\}$ are

$$\text{if } \alpha Kl < h\left(\frac{\alpha\tau_s}{\tau_s + \tau} + \beta \right), \quad \mu = h\left(\frac{\alpha\tau_s}{\tau_s + \tau} + \beta \right), \quad \omega = 0$$

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

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

$$\max_{\alpha,\beta} \quad K^2l^2\left[(1-\beta)\alpha - \frac{\alpha^2}{2}\right]$$

$$= \max_{\alpha,\beta} \quad K^2l^2\left[\frac{1}{2}(1-\beta)^2 - \frac{1}{2}(1-\beta-\alpha)^2\right].$$

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, $\alpha Kl \geq h\left(\frac{\alpha\tau_s}{\tau_s+\tau} + \beta\right)$, 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 $\beta = 1$.   ‖

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 $\mu^\dagger = h\left(\frac{\tau_s}{\tau_s+\tau}\alpha^\dagger + \beta^\dagger\right)$ 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 (18).

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

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

$$\geq (1-\alpha^\dagger-\beta^\dagger)h\mu^\dagger + \delta^\dagger.$$

In the purely speculative case when $\alpha^\dagger Kl > h(1 + \gamma\,\Sigma l^2)\left(\frac{\alpha^\dagger\tau_s}{\tau_s+\tau} + \beta^\dagger\right)$, it is 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 (20), the manager's short-term effort choice improves the welfare of himself/herself and the incumbent shareholders for the optimal contract in an efficient market in which short-termist behaviour is not rewarded. Therefore, the equilibrium contract in the new speculative environment must also motivate some short-term effort from the manager.   ‖

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 (22), and the CEO can be increased in a speculative market under the conditions in (23) from the corresponding level in an efficient market. The gain comes from allowing the manager to sell early to an overvalued 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

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

the welfare of the manager is

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

and the sum is

$$L^{\dagger}_{\text{shareholders}} + L^{\dagger}_{\text{CEO}} = h\mu^{\dagger} - \frac{1}{2}(\mu^{\dagger})^2 - \frac{\gamma}{2}\left[\frac{1}{\tau}\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)^2 + \frac{(\alpha^{\dagger})^2\tau_s}{(\tau_s+\tau)^2} + \frac{(\beta^{\dagger})^2}{\tau_\varepsilon}\right]. \tag{A.2}$$

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

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

the manager's welfare is

$$L^{\ddagger}_{\text{CEO}} = (\alpha^{\dagger}+\beta^{\dagger})h\mu^{\ddagger} + \alpha^{\dagger}Kl\omega^{\ddagger} + \delta - \frac{1}{2}(\mu^{\ddagger}+\omega^{\ddagger})^2 - \frac{\gamma}{2}\Sigma l^2(\omega^{\ddagger})^2$$

$$- \frac{\gamma}{2}\left[\frac{1}{\tau}\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)^2 + \frac{(\alpha^{\dagger})^2\tau_s}{(\tau_s+\tau)^2} + \frac{(\beta^{\dagger})^2}{\tau_\varepsilon}\right],$$

and the sum is

$$L^{\ddagger}_{\text{shareholders}} + L^{\ddagger}_{\text{CEO}} = h\mu^{\ddagger} + (1-\lambda)(1-\beta^{\dagger})Kl\omega^{\ddagger} - \frac{1}{2}(\mu^{\ddagger}+\omega^{\ddagger})^2 - \frac{\gamma}{2}\Sigma l^2(\omega^{\ddagger})^2$$

$$- \frac{\gamma}{2}\left[\frac{1}{\tau}\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)^2 + \frac{(\alpha^{\dagger})^2\tau_s}{(\tau_s+\tau)^2} + \frac{(\beta^{\dagger})^2}{\tau_\varepsilon}\right]. \tag{A.3}$$

We can directly compare the aggregate welfare in equations (A.2) and (A.3):

$$M = L^{\ddagger}_{\text{shareholders}} + L^{\ddagger}_{\text{CEO}} - (L^{\dagger}_{\text{shareholders}} + L^{\dagger}_{\text{CEO}})$$

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

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

$$M = \left[(1-\lambda)(1-\beta^{\dagger}) - \frac{\alpha^{\dagger}}{2}\right]Kl\frac{\alpha^{\dagger}Kl}{1+\gamma\Sigma l^2} - h^2\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right) + \frac{1}{2}h^2\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)^2$$

$$> \left[(1-\lambda)(1-\beta^{\dagger}) - \frac{\alpha^{\dagger}}{2}\right]hKl\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right) - h^2\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right) + \frac{1}{2}h^2\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)^2$$

$$= h\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right)\left\{\left[(1-\lambda)(1-\beta^{\dagger}) - \frac{\alpha^{\dagger}}{2}\right]Kl + \frac{h}{2}\left(\frac{\alpha^{\dagger}\tau_s}{\tau_s+\tau}+\beta^{\dagger}\right) - h\right\},$$

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

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

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

and thus

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

which is positive if

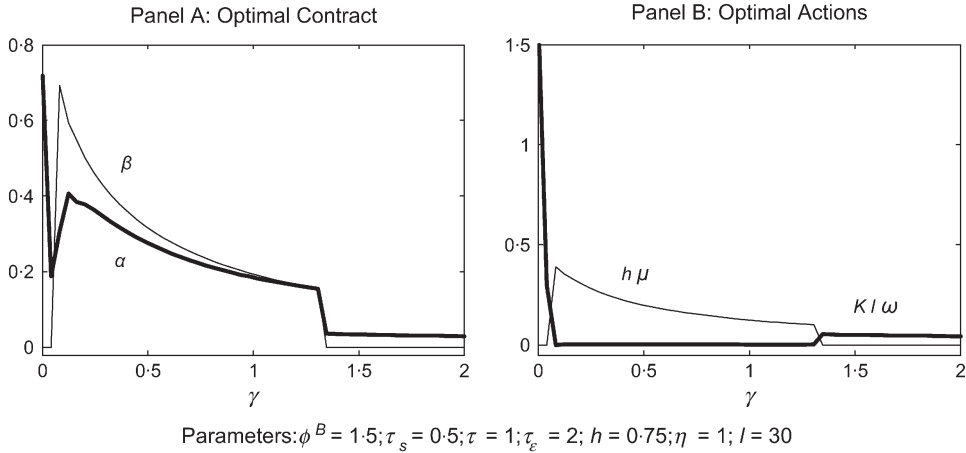$$\omega^{\ddagger} < \frac{2}{\gamma\Sigma l^2}\{(1-\lambda)(1-\beta^{\dagger})Kl - h\}.$$

Panel A: Optimal Contract   Panel B: Optimal Actions

Parameters: $\phi^B = 1\cdot5; \tau_s = 0\cdot5; \tau = 1; \tau_{\varepsilon} = 2; h = 0\cdot75; \eta = 1; l = 30$

FIGURE 1

Optimal contract and actions as a function of γ, for intermediate ϕ^B

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

$$[2(1-\lambda)(1-\beta^{\dagger}) - \alpha^{\dagger}]Kl > h\left[2 - \left(\frac{\alpha^{\dagger} \tau_s}{\tau_s + \tau} + \beta^{\dagger}\right)\right]. \quad \parallel$$

APPENDIX B. NUMERICAL ILLUSTRATIONS WITH A RISK-AVERSE CEO

In this appendix, we provide a series of numerical examples to illustrate the optimal contract and managerial actions when the CEO is risk averse. The numerical solutions reported 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.

B.1. *CEO risk aversion γ*

When secondary markets are efficient, the optimal contract puts positive weight on both short-term and long-term performances 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 performances. 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 in Figure 1 for an intermediate value of ϕ^B.[30]

This figure reveals the somewhat surprising finding that the manager is induced to focus exclusively on the short-term project *both* when his/her coefficient of risk aversion is very small (less than $0\cdot1$ in the illustrated example) and when it is very large (above $1\cdot3$ in our example). When the manager's risk aversion increases above $0\cdot1$ but remains less than $1\cdot3$, he/she switches to pursuing only the firm's fundamental value but his/her compensation is based on a combination of long-term and short-term stock performance. Finally, when the managers's coefficient of risk aversion γ increases beyond $1\cdot3$, he/she switches back to pursuing only the short-term speculative project and his/her compensation is again

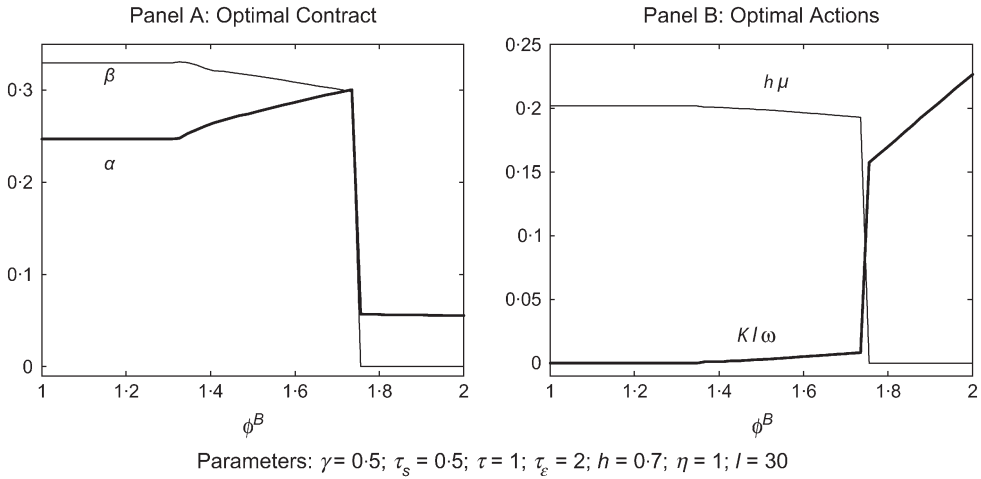30. In a previous version, we also report solutions for high and low values of ϕ.

Parameters: $\gamma = 0.5$; $\tau_s = 0.5$; $\tau = 1$; $\tau_\varepsilon = 2$; $h = 0.7$; $\eta = 1$; $l = 30$

FIGURE 2

Optimal contract and actions as a function of ϕ^B

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 him/her to pursue the long-term value of the firm. Therefore, in equilibrium, the manager scales back his/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.

B.2. *"Overconfidence" parameter 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 his/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.

B.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. This can be seen clearly in Figure 3.

Similarly, when the manager's effort on the castle-in-the-air project is 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 disagree sufficiently with group-A investors. This is illustrated in Figure 4 for $\phi^B = 2$.

B.4. *Fundamental risk τ, τ_s, and τ_ε*

Given a fixed compensation contract $\{\alpha, \beta, \delta\}$, the CEO is likely to increase his/her effort μ when the precisions τ, τ_s, and τ_ε increase, since investment in the long-term project exposes him/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 a small value of τ, 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
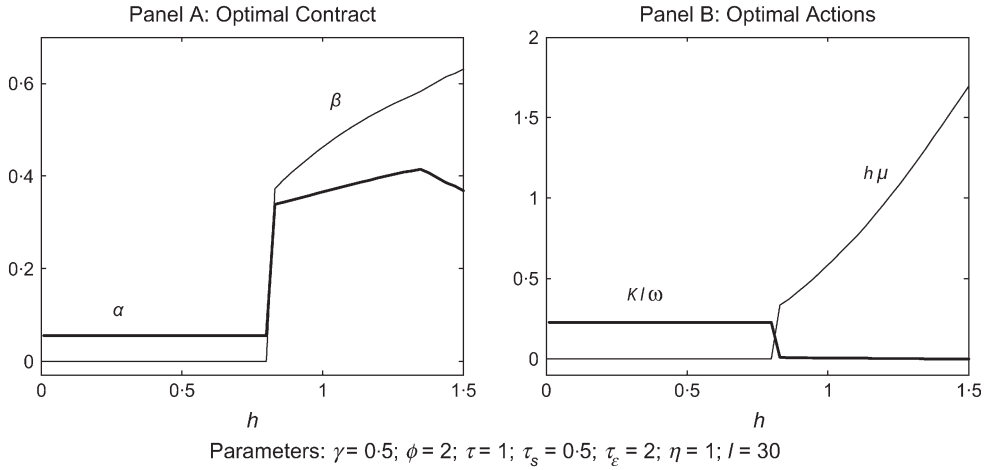
Panel A: Optimal Contract   Panel B: Optimal Actions

Parameters: $\gamma = 0.5$; $\phi = 2$; $\tau = 1$; $\tau_s = 0.5$; $\tau_\varepsilon = 2$; $\eta = 1$; $l = 30$

FIGURE 3

Optimal contract and actions as a function of h

Panel A: Optimal Contract   Panel B: Optimal Actions

Parameters: $\gamma = 0.5$; $\phi = 2$; $\tau_s = 0.5$; $\tau_\varepsilon = 2$; $\tau = 1$; $h = 0.7$; $\eta = 1$
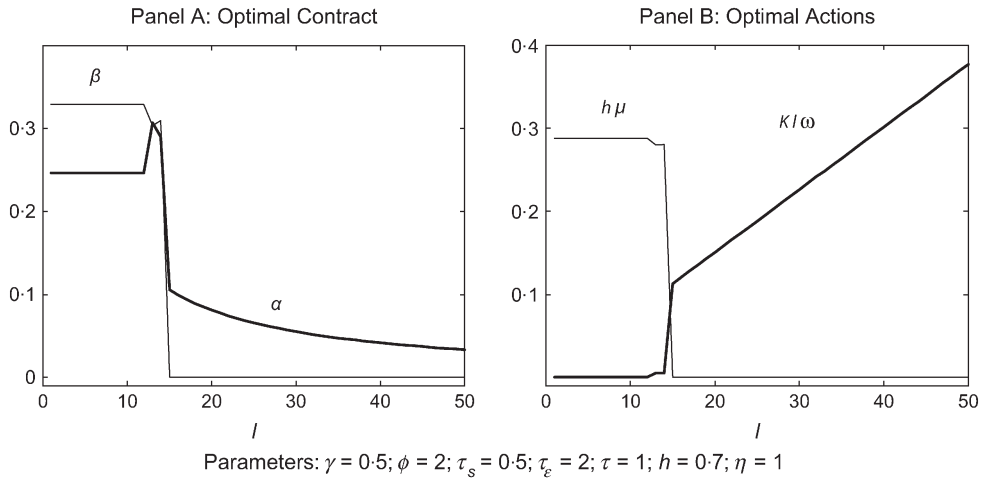
FIGURE 4

Optimal contract and actions as a function of l

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 long-term performance.[31]

B.5. *Share issuance q*

Figure 6 shows that as a long-term-oriented board needs to issue more shares at $t = 1$ (bigger q), the optimal contract shifts more weight to short-term stock participation through α and consequently the CEO will put more effort to the castle-in-the-air project.

31. 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.
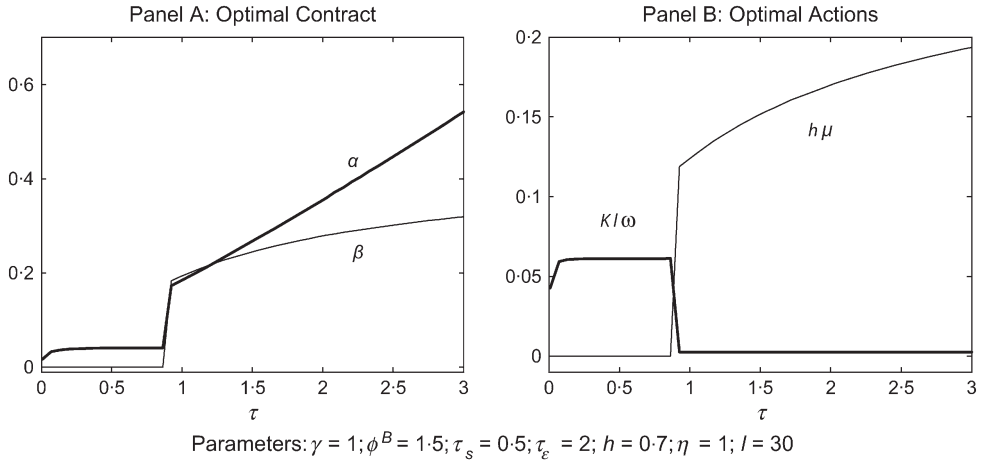
Panel A: Optimal Contract Panel B: Optimal Actions

Parameters: $\gamma = 1; \phi^B = 1 \cdot 5; \tau_s = 0 \cdot 5; \tau_\varepsilon = 2; h = 0 \cdot 7; \eta = 1; l = 30$

FIGURE 5

Optimal contract and actions as a function of τ

Panel A: Optimal Contract Panel B: Optimal Actions

Parameters: $\gamma = 0 \cdot 05; \phi = 1 \cdot 5; \tau_s = 0 \cdot 5; \tau = 1; \tau_\varepsilon = 2; h = 0 \cdot 7; \eta = 1; l = 100$
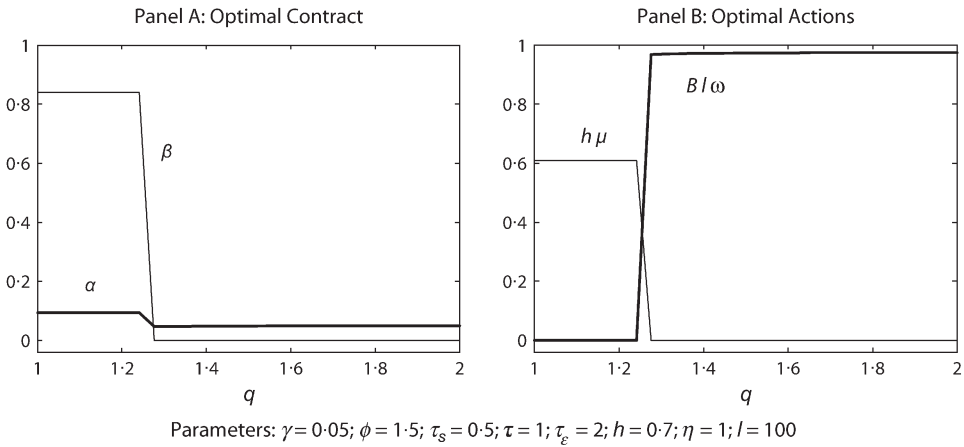
FIGURE 6

Optimal contract and actions as a function of q

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