Corporate Fraud and Overinvestment in Efficient Capital Markets[1]

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Abstract

Overinvestment in certain firms or sectors induced by corporate fraud, where informed insiders strategically manipulate outside investors' beliefs by exaggerating financial performance and economic prospects, has been endemic historically, and has recently attracted much attention. We present a theory that reconciles corporate fraud and overinvestment in efficient capital markets, building on shareholder-manager agency conflicts and the presence of active takeover markets. Shareholders attempt to design managerial compensation contracts and investment policies to elicit valuable information from insiders. But investments that are *ex post* inefficient (i.e., not Bayes-consistent) are not renegotation-proof. Consequently, for a wide range of conditions, the *optimal* contract induces *overstatements* by managers, i.e., exaggerated disclosures regarding future investment opportunities, and subsequent *overinvestment* by rational investors. Our framework helps explain why instances of corporate fraud and overinvestment tend to follow the introduction of new technologies, concentrate in industries with valuable growth options, and intensify when the cost of external financing is low. We also link managerial career concerns to the likelihood of overinvestment, compare information precision in internal versus external capital markets, and provide a new perspective on the design of corporate charters.

Keywords: Overinvestment; Fraud; Agency conflicts; Takeovers; Renegotiation-proof

JEL classification codes: G31, D23, D82

1 Introduction

Corporate fraud has attracted much attention recently because of prominent cases of corporate malfeasance where insiders were able to attract investment through overly-optimistic representations of financial performance and economic prospects (e.g., Worldcom and Enron). An important consequence of this type of fraud is *overinvestment* in certain industries or sectors when uninformed investors direct capital flows to not only the firms manipulating investor beliefs but the entire industry. Worldcom's claim in 1996 — since proved fraudulent — that Internet traffic was doubling every 100 days not only bolstered its own stock price but also appears to have led to a glut in fiber-optic capacity (see, e.g., Dreazen (2002) and Sidak (2003)). But while Worldcom and Enron are recent examples, manipulation of outside investors by strategic insiders through excessively optimistic portrayals of investment prospects has a long history, and appears to have existed from the onset of organized trading and investment.[1]

More generally, there is substantial empirical evidence in the literature suggesting that manipulations of performance measures by insiders lead to overinvestment. For example, Teoh et al. (1998a,b) find that earnings management prior to IPO's and SEO's can explain long-term underperformance. Dechow et al. (1996) find that firms that commit fraud tend to have higher ex ante needs for additional funds. Similarly, Wang (2004) finds that fast growing firms with large external financing needs are likely to commit fraud.

The Worldcom and Enron cases point to the role of asymmetric information in inducing overinvestment. For example, Worldcom's misrepresentations on the rate of growth of Internet traffic had credibility because such information is highly proprietary to carriers. In fact, Sidak (2003, page 230) notes that "...Worldcom used [the] asymmetry of information to exaggerate the value of its stock by overstating the growth of Internet volumes." But this assertion, along with empirical findings emphasizing overinvestment as an attendant cost of corporate fraud, appear puzzling because in efficient capital markets strategic managerial disclosures aimed to inflate firm prospects should be discounted by rational market participants (e.g., Stein (1989) and Narayanan (1985)).

Indeed, corporate finance models with adverse selection often predict *underinvestment* rather than overinvestment, because of the adverse selection problem in equity financing (e.g., Myers and Majluf (1984) and Greenwald, Stiglitz and Weiss (1984)) or capital rationing by debt markets (e.g.,

[1] Notable early examples include the South Sea Trading Company in the seventeenth century and Utilities in mid-western states in the 1920s. Skeel (2005) provides and interesting discussion and numerous other examples of this phenomenon.

Stiglitz and Weiss (1983)).[2]

Our contribution is to develop a theory where fraud and overinvestment jointly occur in a rational expectations equilibrium, i.e., firms with low expected returns receive more than their efficient levels of investment capital even when investors follow their Bayes-rational or individually efficient investment policies. Our framework is built on two fundamental characteristics of modern corporations operating in well developed financial markets. There are shareholder-management agency conflicts because firms are controlled by self-interested managers with private information (e.g., Stulz (1990) and Hart (1995)). And there exist active takeover markets that tend to arbitrage away profits from the acquisition of transparent undervalued assets (e.g., Grossman and Hart (1986)).

Agency conflicts motivate the development of incentive contracts to induce information transmission from privately informed managers. But, as is well–known, in order to provide cost-effective incentives to induce truthful information, *ex ante* incentive-efficient contracts typically require precommitment to policies that are inefficient *ex post* (i.e., conditional on knowing the true state of the world). Specifically, if managers are privately informed about the capital productivity of the firm, then the *ex ante* incentive-efficient contract will prescribe investment levels that are inefficient *ex post.* However, the said inefficiency leads to a transparent undervaluation of the firm, and therefore generates a profitable takeover opportunity, because a subset of investors can earn arbitrage profits by acquiring control of the firm and 'resetting' investment to the *ex post* efficient levels.

In (incentive) mechanism design terms, there is a limited commitment or (contract) renegotiation problem (see, e.g., Bolton and Dewatripont (2005) and Bester and Strausz (2006)) regarding future investment policies, leading to a dilution of incentives for truthful reporting by the privately-informed insiders. Indeed, under plausible ownership and contracting conditions, *any* renegotiation-proof investment policy (i.e., one that does not generate profitable takeover opportunities) must be *ex post* efficient. We therefore highlight the influence of an active corporate takeover market on the design of incentive contracts between managers and shareholders, and provide an institutionally compelling motivation for the "renegotiation-proofness" problem (e.g., Dewatripont (1988)).

Our main insight is that the *ex post* investment efficiency constraint (so to speak) substantially affects the allocation of capital when managers have private information. This is because shareholders cannot provide incentives for truth-telling to informed managers by committing to

[2] Other agency models that emphasize the asset substitution problem (Jensen and Meckling (1976)) and the debt overhang problem (Myers (1977)) also lead to underinvestment. See Stein (2001) for a very useful survey.

investment distortions that are incentive-efficient *ex ante*, but inefficient *ex post*. Of course, shareholders also attempt to design managerial compensation contracts to elicit valuable information from insiders (e.g., Dybvig and Zender (1991)). We find, however, that inducing truth-telling is not always incentive-efficient when the current shareholders can not precommit to arbitrary investment policies, because the incentive cost of inducing truth-telling now falls entirely on the managerial compensation contracts rather than on both investment and wage contracts.

Our analysis indicates that for a wide-range of situations, the *optimal* compensation contract induces misreporting by insiders with a positive probability. In particular, managers in low productivity states sometimes falsely (or fraudulently) inflate reports of their economic prospects, inducing over-investment (relative to the complete information capital allocation) from Bayes-rational investors. Comparative-statics analysis around this fraud-overinvestment equilibrium indicates that the likelihood of fraud is higher for firms with high growth options; it is also higher when the cost of external financing is low (i.e., when the risk-free rate or the equity-premium are low).

The desire to understand the causes and consequences of (corporate) fraud as an equilibrium phenomenon dates at least back to Becker (1968). Stein (1989) argues that myopic managers emphasize short-term financial performance (e.g. stock price and earnings) at the expense of long-term economic value, and therefore (inefficiently) transfer cash flows from future periods to boost current earnings. In equilibrium, however, the market rationally reacts to such behavior by insiders and discounts the current earnings while evaluating the firm. Others who emphasize the role of managerial myopia are Narayanan (1986), Von Thadden (1995), Fischer and Verrecchia (2000), and Kedia and Philippon (2005). Such myopia is sometimes motivated through imperfections in long-term incentive contracting. In our analysis, however, we do not rely on managerial myopia, nor do we impose restrictions on the ability to design long-term incentive contracts.

Our analysis is, thus, more closely related to papers that study optimal compensation contracts when managers can distort information. Goldman and Slezak (2006) analyze a model in which the manager faces a moral hazard problem, and Dye (1988) and Demski (1998) analyze models in which communication is limited.[3] We consider an adverse selection model and do not impose assumptions that limit the ability of insiders to efficiently communicate their information. In

[3] In Goldman and Slezak (2006), the optimal compensation contract balances incentives to exert effort against the agent's desire to commit fraud. In Dye (1998), there is asymmetric information of two dimensions while the informed agent can only provide a one-dimensional report — leading to non-truthful reporting (with some probability). In Demski (1998), earnings management is actually beneficial since that is the only way the manager can communicate the level of future earnings.

particular, under certain parameter regions insiders choose not to truthfully communicate their information even though they can. More importantly, our analysis differs from the above three analyses as it emphasizes the role of capital markets through which managers have damaged their companies in several corporate scandals.[4]

Instead of relying on managerial myopia, limitations on communication, multi-tasking, or investor irrationality, we focus on the financial markets' inability to resist any value increasing investments. In our analysis we allow the design of optimal long-term managerial incentive or compensation contracts. That well-developed (or relatively frictionless) financial markets will exploit the profit opportunities afforded by transparent undervaluation of assets is a compelling argument; therefore, our perspective appears to rest on rather unexceptionable foundations.

The clustering of corporate fraud overtime has been the concern of a few recent studies. In Povel et al. (2005) and Hertzberg (2003), beliefs regarding firms' *productivity* play a key role in determining the likelihood of fraud.[5] Both analyses predict more frequent incidents of fraud when investors are (rationally) optimistic about firm productivity. We, however, link corporations' cost of capital (or investors' risk premia) to the likelihood of fraud. In our framework, the incidence of fraud is time-varying; for example, following industry life cycles (e.g., Klepper (1997)) and the pattern of time-variation in market risk premia (e.g., Lettau and Ludvigson (2001)).

More broadly, our paper is related to the agency literature where constraints on the principal's ability to credibly precommit ex-ante limit the amount of information he possesses ex-post (e.g., Crawford and Sobel (1982) and Laffont and Tirole (1988)). Two related applications of this idea are Arya et al. (1998) and Krasa and Villamil (2000).[6] The focus of these analyses, however, is quite different as they do not address the link between corporate fraud and investment.

We organize the remaining paper as follows. Section 2 sets out the basic model. Section 3 defines optimal contracting and its equilibrium representation. Section 4 provides an intuition for our main result. Section 5 develops the equilibrium with fraud and overinvestment. Section 6

[4] There is also a more recent literature that assumes some market irrationality in reconciling fraud with market equilibrium. Notable examples include Jensen (2004) and Bolton et al. (2004).

[5] When investors are optimistic about firm prospects, in Povel et al. (2005) auditors have weaker incentives to monitor, and in Hertzberg (2003) owners are more likely to use pay-for-performance contracts.

[6] In Arya et al. (1998), the owner cannot commit to a long term employment contract with the manager; earnings manipulation by the manager is then sometimes optimal because it reduces the owner's propensity to replace the manager following low reported earnings. Krasa and Villamil (2000) consider a costly state verification model when the lender cannot commit to an auditing schedule. The optimal contract resembles a simple debt contract, where auditing occurs in the case of a default, and in equilibrium the entrepreneur falsely reports cash flows with some probability.

discusses some extensions and implications of the model, and Section 7 concludes. All proofs are placed in the Appendix.

2 The Model

2.1 Technology

There are three time periods in the model, $t = 0, 1, 2$. The firm has a point input-point output technology that stochastically converts investment at time $t = 1$, denoted by k, to earnings at time $t = 2$, denoted by y. For given investment, the expected earnings depend on the capital productivity of the firm, which is uncertain ex-ante.

To make our point in the simplest possible way, we suppose that earnings take only two possible values: a high value, $y = 1$, and a low value, $y = 0$. However, the probability distribution of earnings is influenced by the firm's economic prospects (or productivity), $s \in \{s_h, s_\ell\}$, $1 > s_h > s_\ell$, and investment. The probability of high earnings is given by $sf(k)$, where f is an increasing, concave, and non-negative valued function defined on the feasible investment set $[0, k^{\max}]$, such that $f(0) = 0$ and $f(k^{\max}) \leq 1$.

2.2 Ownership, Control, and Managerial Preferences

The firm is publicly held and its shares are traded in a frictionless capital (or equity ownership) market with a continuum of risk-neutral and non-atomic investors, $z \in Z$, with a common opportunity cost of investment, namely, the gross return $R > 1$. At time $t = 0$, there are a continuum of non-atomic equity holders, $x \in X \subseteq Z$. Equity-ownership is described by the mapping, $\alpha : X \rightarrow [0, 1]$, so that $\alpha(x)$ denotes the fraction of the equity held by investor x.[7]

The firm is controlled by a manager who receives two types of utility from managing the firm. He receives utility from consuming wages, w, that are paid at the time of firm's liquidation. The manager also receives benefits from control. These benefits are a mixture of subjective utility and non-contractible pecuniary benefits, and they increase with the size of the capital assets.

The manager's attitudes toward risk are described by a concave and strictly increasing von-Neumann-Morgenstern expected utility function, $u : R_+ \rightarrow R_+$. And his private benefits from

[7] For simplicity, we assume that the firm is unlevered — our results are materially unchanged if we relax this assumption. And while the assumption of non-atomic owners is notationally convenient, our main results will be robust to more general ownership patterns (see Section 3.7).

control are represented by a strictly increasing and concave function $b : [0, k^{\max}] \rightarrow R_+$ (with $b(0) = 0$). The manager has no initial wealth and enjoys limited liability, and therefore wages must be non-negative. Finally, the manager's reservation utility is normalized to zero.[8] The manager's utility from wage w and investment level k is,

$$U(w, k) = u(w) + b(k). \tag{1}$$

Firm ownership and control, however, may vary over time. At time $t = 1$, any subset of investors (i.e., a "buyout group") may gain control of the firm by offering a take-it-or-leave-it tender offer to the initial shareholders, X. The firm is liquidated, at the beginning of time $t = 2$, upon the realization of y. The terminal payoff to the current owners of the firm given an investment level k, output y, and wage w is,

$$v(w, k, y) = y - w - Rk. \tag{2}$$

2.3 Information

The manager privately observes the productivity of the firm (i.e., the realization of s) before investment takes place, i.e. before time $t = 1$. The manager and the investors share a common prior belief about the possible realizations of s. Specifically, the probability of observing s_h and s_ℓ is μ and $1 - \mu$, respectively (it will sometimes be convenient to put $\mu_h = \mu$ and $\mu_\ell = (1 - \mu)$). All investors know that the manager will privately observe s. Everything else in the model, besides the realization of s, is observable and common knowledge.

3 Contracting and the Market for Control

From an institutional perspective, shareholders delegate the responsibility of wage contracting (with management) to the board of directors. These employment contracts are enforceable in the sense that managers can move the courts to enforce prior wage contracts even though the ownership of the firm changes on a daily basis, as the set of equity holders itself changes.[9] However, owners'

[8] Our results regarding the optimality of a noisy revelation equilibrium do not rely on the manager having a zero reservation utility. A noisy revelation equilibrium can still be optimal for a strictly positive reservation utility as long as the manager earns rents in equilibrium - i.e., the reservation utility is sufficiently low.

[9] Indeed, there is much recent evidence that CEOs, at least in the US, are able to successfully enforce their employment contracts, especially the payment of large severance payments that are specified in the original contract, in the event of job termination and the sale of the firm (see, e.g., Murray (2006) and Lublin and Thurm (2006)). The

ability to credibly *commit* to arbitrary investment is constrained by the possibility of a change in control of the firm *ex post* through a takeover; the new owners can legally choose any desirable investment level.

To see the basic point, imagine a candidate incentive mechanism that specifies an arbitrary investment response following a truthful communication by the manager about the firm's productivity. That is, the mechanism (for incentive-efficiency considerations) requires the current shareholders of the firm to follow an investment policy that does not maximize efficiency *ex post* (following the knowledge of the firm's true productivity). But the transparently inefficient investment (and attendant financial) policy will lead to an undervaluation of the firm's assets relative to the *ex post* efficient investment level. And transparent under-valuation is not a viable situation with a frictionless market for control. This is because there is a clear positive NPV opportunity for some subset of investors to purchase the firm at the under-valued price, re-set the investment to the *ex post* efficient level, and sell (or even hold) the firm for a sure expected gain.

We can incorporate the commitment issues with respect to investment by appealing to the notion of *renegotiation-proof* mechanisms or contracts, and using this well-developed analytical framework (see, e.g., Bolton and Dawatripont (2005)). The mechanism described in the previous paragraph is not renegotiation-proof because potentially there are incentives for a subset of investors to offer an alternative arrangement — implemented by purchasing the shares of the current shareholders — so that all the shareholders are at least as well-off, and some shareholders are strictly better off.

3.1 Incentive Mechanisms or Contracts

We will allow the manager to communicate with the owners regarding his private information on the firm's productivity. Owners can therefore design an incentive mechanism (or 'contract') at the beginning of time $t = 0$ that is contingent on the manager's communication of the productivity. This communication occurs later during this time-period, following the manager's observation of the actual productivity. The contract is a wage and investment menu. It determines the manager's wages as a function of his communication and the observed earnings at time $t = 2$; it also determines the investment allocation as a function of the manager's communication. However, the investment may change if the ownership changes (prior to the investment decision). This is because investment at any given point in time is legally the domain of the *current* capital owners.

ex post inflexibility of these employment contracts seems to even surprise boards who inked the contracts in the first place (Dash (2006)).

if it is mutually agreeable. The possibility of investment revision or renegotiation implies that the Revelation Principle fails to hold in our setting.[10]

A contract therefore specifies a noisy reporting policy for the manager, contingent on his type; it specifies, as well, an investment policy that is contingent on the report, and a managerial wage policy that are contingent on the report and the observed earnings. Specifically, let π_{jr} be the probability that a manager with an actual productivity j reports the productivity r, for $j, r \in \{\ell, h\}$. Similarly, the investment policy (or menu) is, k_r, while the wage policy (or menu) is, $\{w_r^+, w_r^0\}_{r=\ell}^h$, where w_r^+ (w_r^0) denotes the compensation when earnings are positive (zero) and the productivity r was communicated. It is notationally convenient to put $\pi_{jj} \equiv \pi_j$ and $\boldsymbol{\pi} = (\pi_\ell, \pi_h)$. Similarly, we let, $\mathbf{k} \equiv (k_\ell, k_h)$, and $\mathbf{w} = (w_\ell^+, w_\ell^0, w_h^+, w_h^0)$. A contract is the profile $\mathbf{C} = \{\boldsymbol{\pi}, \mathbf{w}, \mathbf{k}\}$.[11]

3.2 The Takeover Process

At time $t = 1$, after the manager's communication but prior to the investment decision, any bidder — an individual investor or a subset of investors — can make a take-it-or-leave-it tender offer for the firm to its current owners (or equity-holders), namely, X. If a majority of the equity-holders accept the offer, then control of the firm passes to the bidder who is then free to alter any pre-announced investment plan, because at the time investment the bidder owns a majority stake in the firm. However, the successful bidder must respect the manager's original wage or employment contract ($\mathbf{w}$), because it is legally enforceable (see footnote 9).[12]

We will say that the mechanism is *renegotiation-proof* if and only if there exists no bidder (at time $t = 1$) who can successfully effect a takeover to change $\mathbf{k}$.

[10] We are confronted with a contracting problem with adverse selection and limited commitment with respect to investment, and in general one may require complex message spaces (or communication devices) to characterize the optimal mechanism (e.g., Kumar (1985) and Forges (1990)). However, since we have only *two* possible agent types, we can restrict attention to noisy communications (or randomizations) on the space of types without loss of generality (see, Bester and Strauz (2006)).

[11] Notice that the manager's wage contract at time $t = 0$ is not directly contractible on the investment at time $t = 1$. As in the incomplete contracts literature (see, Hart and Moore (1988)), we assume that a complete specification of future investment in the corporation is sufficiently complex, and therfoire future verifiability sufficiently costly, to make wage contracts contingent on that investment legally unenforceable. This is in fact what we actually tend to observe (see, e.g., Kole (1997)).

[12] In principle, the new owners could also renegotiate the employment contract if it is mutually agreeable. But notice that the possibility of wage contract renogotiation only facilitates takeovers. For, any takeover opportunity that is profitable with the constraint of of offering $\mathbf{w}$ is profitable *a fortiori* with the possibility of a mutually benficial renegotiation. However, to ease the notational burden and simplify the model specification, we do not consider employment contract renegotiation.

3.3 Timing Conventions

The timing conventions of the model are described in Figure 1 below.

Figure 1

3.4 Complete Information Benchmark

Suppose there is complete information on the productivity. In this case, the efficient investment policy (or *first best*) is denoted by k_j^*, $j = h, \ell$, such that,

$$s_j f^{'}(k_j^*) = R. \tag{3}$$

From concavity and the fact that $s_h > s_\ell$, it follows that $k_h^* > k_\ell^* > 0$. The manager is not given any wage payment with complete information since he enjoys benefits of $b(k_j^*) > 0$ in each productivity state.[13]

3.5 Admissible Contracts and Ex Post Investment Efficiency

A contract $\mathbf{C} = \{\boldsymbol{\pi}, \mathbf{w}, \mathbf{k}\}$ is *admissible* if the noisy reporting policy ($\boldsymbol{\pi}$) is incentive compatible for the manager and if the investment menu $\mathbf{k}$ is renegotiation-proof. We now quantify this notion of admissible contracts.

Given some $(\mathbf{w}, \mathbf{k})$, the manager's payoffs when the true productivity is j, but he reports r, for $j, r \in \{\ell, h\}$ are:

$$U_j(r \,\Big|\, \boldsymbol{w}, \mathbf{k}) = s_j f(k_r)[u(w_r^+) - u(w_r^0)] + u(w_r^0) + b(k_r) \tag{4}$$

[13] More generally, the efficient level of investment under complete information will depend on the manager's reservation utility (which in our caes is zero). Throughout the analysis we assume that $k_h^* < k^{\max}$ - that is to insure that the first best level of investment defined above is feasible. Since the equilibrium levels of investment we establish subsequently will fall short of the first best level of investment k_h^* we disregard this constraint.

Therefore, the manager's expected payoffs when the true productivity is j and he uses the noisy communication policy $(\pi_j,\, 1-\pi_j)$ are:

$$U_j(\pi_j, \boldsymbol{w}, \mathbf{k}) = \pi_j U_j(j \,\big|\, \boldsymbol{w}, \mathbf{k}) + (1-\pi_j) U_j(r \,\big|\, \boldsymbol{w}, \mathbf{k}), \qquad r, j \in \{\ell, h\}, r \neq j \tag{5}$$

Hence, the noisy communication policy $\boldsymbol{\pi} \in \mathbf{C}$ is incentive compatible for the manager if, $\pi_j \in \arg\max_{\hat{\pi}\in[0,1]} U_j(\hat{\pi}, \boldsymbol{w}, \mathbf{k}), \quad j \in \{\ell, h\}$. Next, the renegotiation-proofness constraints on $\mathbf{k}$ can be conveniently specified in terms of excluding a profitable take-over *ex post*. Then, fix some $\mathbf{C}$, and note that the probability of receiving the report $r \in \{\ell, h\}$ (under the given contract) is $q_r(\mathbf{C}) = \mu\pi_{hr} + (1-\mu)\pi_{\ell r}$. Hence, by Bayes rule, the conditional expectation of the productivity state s, following a report r is,

$$E(s|\mathbf{C}, r) = \frac{\mu\pi_{hr}s_h + (1-\mu)\pi_{\ell r}s_\ell}{\mu\pi_{hr} + (1-\mu)\pi_{\ell r}} \tag{6}$$

And the market value of the firm following this report is therefore,

$$V(\mathbf{C}, r) = E(s|\mathbf{C}, r) f(k_r)[1 - w_r^+ + w_r^0] - w_r^0 - Rk_r \tag{7}$$

Then, there is an opportunity to increase firm value *ex post* — i.e., following the report $r \in \{\ell, h\}$ — if there exists some investment level $\hat{k}_r$ that improves expected profits relative to the original investment plan (k_r) in the contract. That is, if,

$$V(\mathbf{C}, r; \hat{k}_r) = E(s|\mathbf{C}, r) f(\hat{k}_r)[1 - w_r^+ + w_r^0] - w_r^0 - R\hat{k}_r > V(\mathbf{C}, r) \tag{8}$$

Furthermore, a renegotiation opportunity exists if, given (8), a bidder can take over the firm and replace k_r with $\hat{k}_r$. The contract $(\mathbf{C})$ is thus renegotiation-proof if, for each report $r \in \{\ell, h\}$, there exists no $\hat{k}_r$ that is both value-improving (in the sense of (8)) and implementable through a take over.

It turns out that the assumption of competitive (or price-taking) shareholders is sufficient to ensure that any $\hat{k}_r$ that is value-improving is also implementable through a take over. That is, given a $\hat{k}_r$ that satisfies (8), any bidder can make a tender offer to purchase the firm's shares at a price that the shareholders will accept, revise the investment plan, and make positive expected profits. The logical culmination of this argument is that the requirement of renegotiation-proof investment will lead to *ex post efficient* or Bayes-consistent investment. That is, the level of investment that maximizes the value of the firm to its current owners conditional on their beliefs on the firm's productivity, for a given managerial compensation contract. Indeed, we establish the equivalence between renegotiation-proof investment and ex post efficiency through the elimination of profitable takeover opportunities.[14]

Theorem 1 *If the investment policy $k_r, r \in \{\ell, h\}$, is renegotiation-proof (i.e., contractually admissible), then it maximizes the value of the firm conditional on the report r, for any given $\mathbf{w}_r = (w_r^+, w_r^0)$. That is, if $\hat{\mathbf{k}}^* \in \hat{\mathbf{C}}^*$, then, $\hat{k}_r^* \in \arg\max_{k' \geq 0} V(\mathbf{C}, r; k'), r \in \{\ell, h\}$.*

While we have presented a sufficient set of conditions that guarantee *ex post* investment efficiency in the presence of frictionless takeover markets, this result is actually quite robust. For example, it would apply if there was only a single owner of the firm, who (being the sole owner of the capital) would simply revise any prior announced investment in light of the new information or be bought out. With multiple blockholders, the allocation of efficiency gains from revising the investment ex post is more complex, but it is difficult to envisage the survival of ex post investment inefficiency.

3.6 Optimal Contracts

The initial shareholders (i.e., the set X) then choose, at time $t = 0$, an admissible contract that maximizes the *ex ante* value of the firm. Let us denote the set of feasible contracts by Ω.[15]Then, the optimal (renegotiation-proof) contract $\hat{\mathbf{C}}^* = (\hat{\boldsymbol{\pi}}^*, \hat{\mathbf{k}}^*, \hat{\mathbf{w}}^*)$ is a solution to the program,

$$\max_{\mathbf{C} \in \Omega} \sum_{r \in \{\ell, h\}} [\mu \pi_{hr} + (1-\mu)\pi_{\ell r}] V(\mathbf{C}, r; k_r) \quad \text{s.t.,} \tag{9}$$

$$V(\mathbf{C}, r; k_r) \geq V(\mathbf{C}, r; \hat{k}_r), \text{ for all } \hat{k}_r \in [0, k^{\max}], \text{ and } r \in \{\ell, h\} \tag{10}$$

$$U_j(\pi_j, \mathbf{w}, \mathbf{k}) \geq U_j(\hat{\pi}, \mathbf{w}, \mathbf{k}), \text{ for all } \hat{\pi} \in [0, 1], \text{ and } j \in \{\ell, h\} \tag{11}$$

$$k_r \geq 0, w_r^+ \geq 0, \; w_r^0 \geq 0, \quad r \in \{\ell, h\}. \tag{12}$$

[14] We impose a regularity condition on investors' strategies, namely, that defections by sets of measure zero shareholders do not affect the behavior of other investors. This restriction on players' strategies is widely used in the bargaining literature where competitive or price-taking behavior is important (see, e.g., Gul et al. (1986), Ausubel and Deneckere (1989) and Kumar (2006)). Here, this regualrity condition formalizes the notion that individual shareholders are *price-takers* in the capital markets.

[15] As $\mathbf{C}$ is completely specified by the profile $(\pi_h, \pi_\ell, k_h, k_\ell, (w_\ell^+, w_\ell^0, w_h^+, w_h^0))$, it follows that $\Omega = [0, 1]^2 \times R_+^6$.

3.7 Equilibrium Representation of Optimal Contracts

Theorem 1 above implies that in any optimal contract, the investment $\mathbf{k}$ must be optimal given the posterior (or revised) beliefs of the investors, conditional on the manager's report. That is, $\mathbf{k}$ must be a Bayes-rational rule. This observation suggests that the optimal contract (cf. Equation (9)) may be represented through a slightly modified form of the Perfect Bayesian Equilibrium (PBE) (see, e.g., Fudenberg and Tirole (1991)) — the modification being required to accommodate the contractually fixed managerial wages.

Specifically, a given wage policy, $\mathbf{w}$, defines a noncooperative game with incomplete information with associated strategies $\boldsymbol{\pi}$ (from the manager) and $\mathbf{k}$ (from the investors). The manager's reporting strategy $\boldsymbol{\pi}$ and the owners' investment response to reports $r \in \{\ell, h\}$, $\mathbf{k}$, comprise a PBE if (1) $\boldsymbol{\pi}$ is optimal given the $(\mathbf{k}, \mathbf{w})$, (2) $\mathbf{k}$ is optimal given $\mathbf{w}$ and updated beliefs regarding the firm's productivity, denoted by $\beta(s; r)$, and (3) the beliefs $\beta(s; r)$ are derived using Bayes' rule whenever possible. It is easy to check that any contract $\mathbf{C} = \{\boldsymbol{\pi}, \mathbf{w}, \mathbf{k}\}$ is optimal (in the sense of (9)) iff it is a PBE in the game defined by $\mathbf{w}$. Finally, $\mathbf{w}$ is chosen to maximize firm value, taking as given the menu $(\boldsymbol{\pi}, \mathbf{k})(\mathbf{w})$ that specifies an equilibrium $(\boldsymbol{\pi}, \mathbf{k})$ for each $\mathbf{w}$.

4 Noisy Communication Equilibrium

In the PBE developed in the previous section, owners have significant influence on the information content or accuracy of the manager's reports through the initial design of the wage policy. A main result of this paper is that, for an open set of parameters, there is a unique equilibrium that has the manager misreporting the firm's true economic state with positive probability. That is, there is noisy revelation of the firm's economic state in equilibrium. Before deriving this result formally in the section 5 we would like to provide further intuition through the following *informal* discussion.

The set of admissible contracts includes two contracts that are polar opposites in terms of the information they induce from the manager: a contract that implements truthful reports made by the manager, and a contract that implements non-informative reports. In the former, the equilibrium of the noncooperative game defined by $\mathbf{w}$ is a fully revealing separating equilibrium, while in the latter it is a pooling equilibrium. However, these are not the only admissible contracts; noisy revelation contracts may also be admissible.

Consider a candidate contract with wage schedule $\mathbf{w}$ for which truth telling by the manager and the first-best levels of investment, namely, k_h^*, k_ℓ^*, are a PBE. A simple example of such a contract is one in which $w_\ell = w_\ell^+ = w_\ell^0$, and $0 = w_h^+ = w_h^0$. Clearly, truth-telling is an equilibrium strategy if the manager is indifferent between sending his two possible reports, i.e., $u(w_\ell) + b(k_\ell^*) = b(k_h^*)$. But notice that while this contract attains the first best investment level, it imposes a (managerial) compensation cost because the manager extracts rents from the owners.

On the other extreme, consider a candidate contract for which non-informative managerial reports are a PBE. A simple example for such a contract is one in which $0 = w_\ell^+ = w_\ell^0 = w_h^+ = w_h^0$, and $k_\ell = k_h = k^p$, where k^p represents the optimal level of investment given a non-informative report.[16] But while this pooling contract does not impose a compensation cost, it is costly for the owners on another dimension, namely, the investment inefficiency relative to the first best.

In general, the trade-off between efficient allocation of capital and the (managerial) compensation cost of extracting information will determine whether the completely revealing or the pooling contract is superior in terms of shareholder value. But the compensation cost of (inducing) truthful revelation can be large if the first-best investment gap between high and low productivity states (i.e., $k_h^* - k_\ell^*$) is high.

It follows (from the Envelope Theorem) that if investors could commit to a marginally lower investment (relative to k_h^*) following a truthful report of the high state of productivity, then their welfare will be improved. Indeed, an analysis of the *second-best* investment levels (say, $\bar{k}_r$, $r \in \{\ell, h\}$) shows that the dispersion across productivity states is always lower relative to the first-best, i.e., $(\bar{k}_h - \bar{k}_\ell) < (k_h^* - k_\ell^*)$.[17] But as we have emphasized above, such a investment levels are not renegotiation-proof, because they lead to a common knowledge undervaluation of the firm, i.e., they violate constraint (10).

A natural possibility for achieving such (desired) investment distortion in equilibrium is through a contract in which the manager strategically misreports productivity with a positive probability in the low state. Such (equilibrium) noisy communication will dampen investors' Bayes-rational response to a high-productivity report and will therefore reduce the investment gap between the high- and low-productivity states. However, this "solution" is costly because it leads to *over investment* in the bad state (relative to the first-best) whenever misreporting occurs. We now analyze this trade-off and derive conditions under which investors optimally choose the wage-incentive mechanism to support noisy communication or fraud in equilibrium.[18]

[16] Formally, k^p is implicitly given by, $[\mu s_h + (1-\mu)s_\ell]f'(k^p) = R$.

[17] Details on the second-best are available from the authors.

[18] We also analyze alternative mechanisms for dampening investment in the high state.

5 Equilibrium Fraud and Investment Inefficiency

In this section, we demonstrate the existence of, and characterize, a noisy revelation equilibrium where investors optimally design a wage contract that induces fraudulent reporting with positive probability by the low-productivity manager, i.e., $0 < \pi_{\ell h} < 1$, but truthful reporting by the high-productivity manager, i.e., $\pi_{hh} = 1$. Focusing attention to overstatements of economic performance is of particular interest. For example, while exploring data of accounting restatements over the period 1995-2001, Burns and Kedia (2004) report that 93% of restatements involved overstating net income in the year of misreporting. Such overstatement of the firm's economic prospects, by the manager, in the low productivity state, leads to overinvestment relative to the first best.

To facilitate intuition, we work with a parameterization of technology and preferences that allows us to constructively characterize the noisy revelation equilibrium. Let the production technology be given by, $f(k) = 2\sqrt{k}$, and the private benefit be, $b(k) = \psi\sqrt{k}$. Furthermore, we set $u(w) = w^{1/\gamma}$, $\gamma \geq 2$, so that $u(\cdot)$ belongs to the CRRA family.[19]

Wages that are contingent on output not only affect managerial reports (through (11)), but also alter the share of output y allocated to owners, which in turn affects owners' best response investment to managerial reports (through (10)). We therefore conduct the analysis in two stages. First we consider only short term performance contracts that do not specify wages contingent on realized output but only on managerial reports. Such short term contracts do not affect (directly) owner's best response investment but affect managerial reports. Second, we allow contracts to monotonically depend on the terminal output level. Such long term contracts can affect the owner's investment response. In both cases we provide (similar) conditions under which noisy revelation is optimal.[20]

5.1 Short-term Performance Contracts

We first analyze the optimal compensation contract while excluding the possibility of output contingent wages, i.e.,

$$w_j^+ = w_j^0 \equiv w_j, \quad j \in \{\ell, h\}.$$

As we mentioned above, we will construct an equilibrium where the high-productivity manager reveals his state truthfully, but the low-productivity manager over-states his productivity with

[19] In order to make sure that $s2\sqrt{k} < 1$ in equilibrium we suppose that $s_h^2 < R/2$.

[20] Thus, we do not restrict attention to short-term contracts.

positive probability. Therefore, in equilibrium, the high-productivity manager must weakly prefer truthfully reporting the state of productivity, and the low-productivity manager must be indifferent between truthful and untruthful reports. Therefore, (11) can be summarized by, $u(w_h) + \psi\sqrt{k_h} = u(w_\ell)+\psi\sqrt{k_\ell}$. Hence, both manager-types are indifferent between reporting truthfully and untruthfully. Furthermore, owners' best response investment to managerial reports, i.e., constraint (10) can be summarized by,

$$k_j \in \arg\max_{k\in[0,k^{\max}]} E(s|\mathbf{C},j)2\sqrt{k} - w_j - Rk,\ \ j \in \{\ell,h\}$$

The optimal contract $\mathbf{C}^* = (\boldsymbol{\pi}^*, \mathbf{k}^*, \mathbf{w}^*)$ is a solution to the program:

$$\begin{aligned}
&\max_{\pi_{\ell h},k_\ell,k_h,w_\ell,w_h} [\mu + (1-\mu)\pi_{\ell h}][E(s|\mathbf{C},h)2\sqrt{k_h} - w_h - Rk_h] \\
&\quad +(1-\mu)(1-\pi_{\ell h})[E(s|\mathbf{C},\ell)2\sqrt{k_\ell} - w_\ell - Rk_\ell] \qquad s.t. \qquad (13)\\
k_j &= \left(\frac{E(s|\mathbf{C},j)}{R}\right)^2,\ j\in\{\ell,h\} \qquad (14)\\
u(w_h)+\psi\sqrt{k_h} &= u(w_\ell)+\psi\sqrt{k_\ell} \qquad (15)\\
E(s|\mathbf{C},h) &= \frac{\mu s_h + (1-\mu)\pi_{\ell h}s_\ell}{\mu+(1-\mu)\pi_{\ell h}},\ \text{and } E(s|\mathbf{C},\ell) = s_\ell
\end{aligned}$$

The wage policy plays an important role in eliciting information from the manager. As a result, the optimal wage-policy will set zero wages when the manager reports the high-productivity state. To see this, suppose to the contrary that, $w_h > 0$. Then, from $k_h = \left(\frac{E(s|\mathbf{C},h)}{R}\right)^2 \geq k_\ell = \left(\frac{s_\ell}{R}\right)^2$ and (11) it follows that $w_\ell > 0$ as well. However, an increase in the objective function can be achieved by reducing wages w_h and w_ℓ to the levels $\hat{w}_h = 0$ and $\hat{w}_\ell = u^{-1}\left(\psi\left(\sqrt{k_h} - \sqrt{k_\ell}\right)\right)$. Thus, at the optimum we have,

$$u(w_\ell) = \psi(\sqrt{k_h} - \sqrt{k_\ell}) \qquad (16)$$

For computational ease, it is useful to view $u \equiv u(w_\ell)$ as the control variable, and express the optimal contract as a function of u.

Theorem 2 *The optimal contract (cf.(13)) is given by,*

$$k_\ell = \left(\frac{s_\ell}{R}\right)^2,\ k_h = \frac{u}{\psi} + \frac{s_\ell}{R},\ \pi_{\ell h} = \frac{\mu(\psi(s_h - s_\ell) - uR)}{(1-\mu)uR},\ w_h = 0,\ \textit{and } u(w_\ell) = u, \qquad (17)$$

where the control variable u is implicitly defined by the first order condition,

$$F \equiv \gamma R u^{\gamma-1} - [\mu\psi(s_h - s_\ell)] \left(u^{\gamma-2}[\gamma - 1] + \frac{R}{\psi^2} \right) = 0, \tag{18}$$

and provided that $u \in \left[\frac{\mu\psi(s_h - s_\ell)}{R(1+\mu)}, \frac{\psi(s_h - s_\ell)}{R} \right]$.

The above theorem provides a characterization of the noisy revelation equilibrium. Subsequently, we provide necessary and sufficient conditions under which the noisy revelation equilibrium prevails. We proceed, first by establishing a few properties of the noisy revelation equilibrium (when it exists). It is now transparent how the wage-policy (w_ℓ) influences the low-productivity manager's (randomized) reporting strategy (in equilibrium), because $\pi_{\ell h}$ depends on $u(w_\ell) = u$ through (17). An interesting aspect of this randomized reporting strategy is that, in a noisy revelation equilibrium, $\pi_{\ell h}$ and w_ℓ are negatively related; i.e., a higher wage in response to the low-productivity report is associated with a lower probability of over-reporting by the low -productivity manager. Intuitively, shareholders can purchase more truthfulness from the manager in the bad productivity state by increasing his compensation. As discussed later, however, this partial equilibrium intuition, will not hold at the optimum when variables are endogenous. In other words, higher compensation following low managerial reports is positively associated with higher levels of fraud, in equilibrium.

In equilibrium, the optimal u determines the low-productivity manager's reporting strategy $\pi_{\ell h}$ through (17). Comparative statics on (18) then clarify the determinants of w_ℓ.

Proposition 1 *If, in equilibrium,* $0 < \pi_{\ell h} < 1$, *then the certain wage for the low-productivity manager,* w_ℓ, *is increasing in* s_h, *but is decreasing in* R.

In general, higher is w_ℓ, the less the incentive for the manager to over-state the true productivity of the firm; in effect, w_ℓ, is the manager's compensation for truthfully reporting the low-productivity state and accepting a lower investment level. Therefore, w_ℓ will be higher, other things held fixed, if the costs of false reporting of capital productivity are severe for the shareholders. Proposition 1 is therefore consistent with this intuition. Both an increase in value of the growth option, s_h, and a decrease in investors' opportunity cost of capital R increase firm productivity and lead to higher levels of investment (as formally shown in proposition 3 subsequently). Thus, intuitively, the model predicts that w_ℓ will increase as a result (see (16)). An increase in managements' private benefit from control, however, is counter productive, as it leads (only) to stronger incentives for manipulation (all else equal). This, in turn, reduces investment (see proposition 3) and the overall effect on the certain wage for the low-productivity manager is, thus, ambiguous.

The comparative statics on u (or w_ℓ) also clarify the determinants of the equilibrium noisy revelation strategy, $\pi_{\ell h}$ (cf. (17)). This is because $\pi_{\ell h}$ is influenced by the choice of w_ℓ. As standard, for any given parameter x,

$$\frac{d\pi_{\ell h}}{dx} = \frac{\partial \pi_{\ell h}}{\partial x} + \frac{\partial \pi_{\ell h}}{\partial u}\frac{\partial u}{\partial x}. \tag{19}$$

In general, $\pi_{h\ell}$ is determined through the incentive-compatibility condition (for noisy revelation) given in (16). Specifically, if a change in a model parameter *increases* the manager's propensity to over-state the firm's productivity, then $\pi_{\ell h}$ will rise because inducing truthfulness becomes more costly. Thus, $\pi_{\ell h}$ will be increasing in ψ, because the manager's incentives for attracting higher investment through misreporting are greater if his private control benefits are higher. Meanwhile, s_h increases or R falls, the manager receives higher investment from misreporting, and hence we expect that $\pi_{\ell h}$ will be increasing in s_h and decreasing in R.

Proposition 2 *If, in equilibrium,* $0 < \pi_{\ell h} < 1$, *then it is increasing in* s_h *and* ψ, *and decreasing in* R.

We turn now to an analysis of equilibrium investment in the noisy revelation equilibrium. We see from (17) that there is no investment distortion when a low-productivity state is announced under the noisy revelation equilibrium that we consider[21]; i.e., $k_\ell = k_\ell^*$. However, there is clearly overinvestment in the low-productivity state with probability $\pi_{\ell h}$. To be clear, we view overinvestment as the extent of capital misallocation when disclosures are false, i.e., the difference between the equilibrium level of investment, k_h, and the first best level of investment, k_ℓ^*. The extent of overinvestment, thus, depends on investors' beliefs regarding managements' reporting strategy (which are consistent in equilibrium). The effects of changes in the cost of capital (R), the value from investment in the good state (s_h), and managements' private benefits from control ($b(k)$) on the optimal level of overinvestment are deduced from (16).

Proposition 3 *If, in equilibrium,* $0 < \pi_{\ell h} < 1$, *then the extent of overinvestment* $k_h - k_\ell^*$ *is increasing in* s_h, *and decreasing in* ψ *and* R.

[21] We consider a noisy revelation equilibrium with *underreporting* in the extensions section.

Thus, even in the noisy revelation equilibrium, the investment response to a high-productivity report maintains certain efficiency features: it is negatively related to the opportunity cost (R), positively related to the expected capital productivity in that state, but negatively associated with the manager's private benefit from investment (ψ). This implies that when growth options are high or access to capital is at lower cost, then both the probability of overstatements and the extent of overinvestment that follows are higher.

We now turn to examine the feasibility of a noisy revelation equilibrium where $0 < \pi_{\ell h} < 1$. Intuitively, the equilibrium $\pi_{\ell h}$ will lie strictly between 0 and 1 if the costs of inducing information from the low productivity manager are neither too low nor too high. For, if these costs are too low, then it would be optimal to induce the correct information, i..e, $\pi_{\ell h} = 0$. On the other hand, if these costs are very high, then it may be optimal not to induce any information at all, i.e., $\pi_{\ell h} = 1$. In our analysis above, we have related the cost of inducing information to the manager's private benefit of control (ψ) and the cost of capital (R). Indeed, we find that,

Theorem 3 *There exist* $(\underline{R}, \bar{R})$ *and* $(\underline{\psi}, \bar{\psi})$ *such that,*

(i) If $R > \overline{R}$ *(or* $\psi < \underline{\psi}$*), then managerial reports are truthful.*

(ii) If $R < \underline{R}$ *(or* $\psi > \overline{\psi}$*), then managerial reports are not informative.*

(iii) Otherwise, there exists a noisy revelation equilibrium where u *and* $\pi_{\ell h}$ *are given by (18) and (17), respectively, and* $0 < \pi_{\ell h} < 1$.

In the absence of commitment, owners have the choice *ex ante* to set a wage-policy that induces truth-telling from the high-productivity manager, regardless of the opportunity cost of capital, R, and managements' private benefit from control, ψ. An important implication of Theorem 3 is, therefore, that investors' welfare *ex ante* is not necessary maximized under a truth telling mechanism. In particular, truth telling is no longer optimal when investors' required rate of return is low or managements' private benefit from control is high. In such cases, the credible or consistent way for investors to restrict their response to managerial disclosures is to suffer the likelihood that the low-productivity manager will fraudulently over-state the investment prospects of the firm. This in turn reduces managements' expected compensation. Theorem 3 explicates the conditions under which savings from lower managerial compensation costs under noisy revelation offset the investment efficiency loss from the manager's fraudulent reporting.

Corollary 1 *In the noisy revelation equilibrium, a truth telling mechanism results in lower (and thus suboptimal) firm value, V.*

5.2 Example with an Analytic Solution

As an example of Theorem 3, consider the case where $\gamma = 2$ so that $u(w) = \sqrt{w}$. In this case, we can obtain an analytic solution for the optimal wage as,

$$w = \left[\frac{\mu(s_h - s_\ell)(R + \psi^2)}{2\psi R} \right]^2 . \tag{20}$$

Substituting (20) into (17) yields,

$$\pi_{\ell h} = \frac{\psi^2(2-\mu) - \mu R}{(1-\mu)(R+\psi^2)} . \tag{21}$$

For this special value of γ, the equilibrium $\pi_{\ell h}$ is independent of $(s_h - s_\ell)$, while the equilibrium w does depend on these expected productivity parameters.

Returning to Theorem 3, it is easily seen from (21) that,

$$\underline{\psi} = \sqrt{\tfrac{\mu R}{2-\mu}} \quad \bar{\psi} = \sqrt{R}$$
$$\underline{R} = \psi^2 \qquad \bar{R} = \psi^2(2-\mu)/\mu$$

Figure 2 below plots the equilibrium $\pi_{\ell h}$ against μ and R when $\psi = 0.75$. One can see that $\pi_{\ell h}$ falls as the cost of capital rises, which is consistent with Proposition 3. Next, Figure 3 plots the equilibrium $\pi_{\ell h}$ against R and ψ. We see that the equilibrium likelihood of fraud rises as the managerial benefit of control increases. Interestingly, variations in ψ appear to have a greater effect on the equilibrium $\pi_{\ell h}$, at the margin, compared to variations in with respect to R. Next, Figure 4 plots u against R and $D \equiv (s_h - s_\ell)$, the difference in the capital productiveness across the two states. The manager's utility form the wage compensation rises as D increases, and again the impact of changes in D on u, at the margin, exceed those of changes in R.

Finally, Figure 5 graphs the disclosure information regions, in terms of (R, ψ), delineated in Theorem 3, for a parameterization that takes $\mu = 0.05$ and sets $s_h/D = 1.2$. That is, for each value of (R, ψ) in a suitable interval, we compute the corresponding $(\underline{\psi}, \bar{\psi})$ and $(\underline{R}, \bar{R})$ values (cf.

Theorem 3) to identify the pooling, noisy revelation, and separating (or truth telling) regions.[22]

5.3 Long-Term Performance Contracts

In our earlier analysis we have assumed away any possibility of output contingent wages. This was done in order to illustrate the basic point of our paper, in the most intuitive manner. In this section, we complete the analysis to include general compensation contracts. Long-term performance contracts are a potential avenue to influence investors' investment response to managerial disclosures, e.g., dampen the level of investment following a high report by the manager. In particular, any level of *investment* implemented in the noisy revelation equilibrium (e.g., Theorem 3) can be implemented under a truth telling mechanism with output contingent wages. We show, however, that ruling out such contracts does not limit the qualitative implications of our analysis. We restrict attention to monotonic output contingent wage contracts and establish conditions under which the optimal wage schedule does not depend on output.[23]

To illustrate, consider first a truth telling mechanism and recall that $1 - w_h^+$ is the net output received by owners. Ex-post investment in the high state, then, satisfies $s_h f'(k_h)(1 - w_h^+) = R$. Thus, by altering the manager's output contingent compensation, any level of (under) investment can be implemented via this mechanism. More generally, in a noisy revelation mechanism the perceived Bayesian updated probability of the high state following a high report is $\frac{\mu s_h + (1-\mu)\pi_{\ell h} s_l}{\mu + (1-\mu)\pi_{\ell h}}$ and the optimal level of investment solves,

$$\max_k \quad \left(\frac{\mu s_h + (1-\mu)\pi_{\ell h} s_l}{\mu + (1-\mu)\pi_{\ell h}}\right) f(k)[1 - w_h^+] - Rk$$

While the potential advantage of providing output contingent wages lies in the reduction in investment ex-post which in turn leads to lower rents to the manager, it is not without cost. Providing compensation in the good state reduces the owners' claim on realized output. Both mechanisms, non-truthful reporting (or noisy revelation) and, output contingent wages, can mitigate investors' commitment problem at a cost. One would therefore expect the optimal mechanism to include both.

[22] The return R in the graph represents the annual return on a project spanning over the duration of five years, i.e., equals the fifth root of the return over the life of the project (which represents one period in our model).

[23] While the focus on monotonic contracts is common in contract theory (ala Hart and Holmstrom (1987)), it is worth noting that non-monotonic wage contracts might be beneficial in increasing firm value. The possibility for non-monotonic wage contracts, however, does not dismiss the role of noisy revelation.

Our goal in this section is to provide conditions, e.g., regarding the private benefit from control, under which the use of output contingent payoffs is not optimal. This would put in perspective our foregoing results. We start by providing a *necessary* condition for the *optimality* of short-term contracts.

Proposition 4 *There exists $\tilde{\psi}$ such that for $\psi < \tilde{\psi}$, short-term wage contracts are optimal, i.e., $w_h^+ = w_h^0 = 0$ and $w_\ell^+ = w_\ell^0$.*

Intuitively, the rational to use output contingent wages is to decrease investment following a good report and reduce expected wages paid to the manager through the reduction in the investment gap k_h, k_ℓ. The larger are the private benefits from control, the more beneficial it is to reduce the investment gap. Thus, it would be beneficial when private benefits from control exceed the threshold $\tilde{\psi}$. It is worth noting that the condition threshold provided above is a *necessary* condition and the actual private benefit threshold above which output contingent wage contracts become optimal might be higher.

Recall that noisy revelation by the manager is optimal when private benefits from control are neither too high nor too low, i.e., the interval $(\underline{\psi}, \overline{\psi})$ as defined in Theorem 3. In order to better understand the optimality of output contingent wages and noisy revelation by the manager, we next explore the relation between the threshold $\tilde{\psi}$ and the aforementioned interval.

Proposition 5 *The interval $(\underline{\psi}, \tilde{\psi})$ is non-empty, and $\overline{\psi} \leq \tilde{\psi}$ provided that $\frac{s_h}{s_h - s_l} \geq \frac{\gamma(1-\mu)}{2\mu^{\gamma-1}}$; where $\tilde{\psi}$ is as defined in Proposition 4, and $\underline{\psi}$ and $\overline{\psi}$ are as defined in Theorem 3.*

The above proposition confirms that the existence of a noisy revelation equilibrium does not rely on a limitation to short-term performance contracts. In particular, there will always exist an interval (in the spirit of Theorem 3) for which the optimal contract will involve noisy revelation by the manager. Moreover, the theorem provides a condition under which allowing for long-term contracts does not alter the equilibrium.[24] This is summarized as follows.

Theorem 4 *In the general case where long-term (monotonic) performance contracts are considered $\pi_{lh} \in (0, 1)$ for $\psi \in \big(\underline{\psi}, \min(\overline{\psi}, \tilde{\psi})\big)$.*

[24] To illustrate the above condition, suppose that $\mu = 1/2$. The condition, then implies that $\frac{s_h}{s_h - s_l} \geq \gamma 2^{\gamma-3}$. For $\gamma = 2$ this is always the case, while for $\gamma = 3$ this implies $\frac{s_h}{s_h - s_l} \geq 3$.

We conclude that fraud—where insiders over-state the economic prospects of the firm with positive probability—can occur in equilibrium, irrespective of whether performance-contingent contracts can be written or not. Interestingly, performance contracts that induce compensation uncertainty for a risk-averse agent may be optimal even when such contracts worsen risk-sharing without relaxing the *agent's* incentive constraints. This is because such contracts may mitigate the *investors'* commitment problem by influencing their objective function ex post, thereby making their Bayesian-rational investment strategy closer to the ex ante incentive-efficient investment policy.

6 Extensions and Implications

6.1 Corporate Fraud, Overinvestment, and Growth

One important empirical implication of our analysis is that, the likelihood of noisy revelation and subsequent overinvestment are positively related to firms' growth options. In our model, the probability of success can be viewed as a measure of the value of the firm's growth option: the larger is s_h, the more valuable is the option to invest with accurate information. Thus, our model predicts a positive relation between the value of growth options and the likelihood of fraud (Proposition 2). This implication is consistent with the observation that incidences of corporate fraud and overcapacity are common following the introduction of new technologies, and the exploration of new business strategies. In the past, certain industries (and individual firms) suffered more than others during episodes of corporate fraud and overinvestment. Such overinvestment took place, for example, during the South Sea Bubble among firms specializing in global trade; during the nineteenth century in railroads companies; during the 1920's among firms exploiting mass production and utilities companies; and, more recently, among Internet related firms in the 1990s. In each case, overinvestment and fraud were triggered by investors' expectations for high growth either because of the introduction of new technologies or because of exploration of new business opportunities. Such high expectations were often sustained by information provided by insiders (Shleifer (2000), and Sidak (2003)). More systematically, there is evidence for the relation between corporate fraud, overinvestment, and the value of growth options (see, e.g., Wang (2004)).[25]

[25] Wang (2004) uses Securities Class Action Clearinghouse database to explore a sample of 656 U.S. public companies during the years 1996 to 2003 for which lawsuits involving allegations of accounting irregularities where filed, and finds that instances of corporate fraud are more likely in certain industries, such as Telecommunications and Services

6.2 Corporate Fraud, Overinvestment, and Access to Capital

The likelihood of misreporting in our model is negatively related to the investors' required rate of return, i.e., our model predicts that fraud and overinvestment are more (less) likely to occur in periods where firms have easy (costly) access to capital. Indeed, easy access to external funds has been an integral part of several corporate finance scandals throughout history. For example, the South Sea Company obtained the right from the government to convert a large portion of the government debt (held by the public) into company shares, which not only provided substantial access to capital but also motivated the company to mislead investors (Feber (2002)). Similarly, in the 1860's, railroad entrepreneurs copied a major financial innovation of the time—namely, the selling of government bonds to the public rather than only to financial institutions–to finance their rapidly growing industry. As in the case of the South Sea Company, this access to capital was followed by fraudulent disclosures to investors, e.g., the Union Pacific Railroad company (Skeel (2005)). Similarly, during 1920's, a period in which it was "...easier than ever before to raise huge amounts of capital.." (Skeel (2005) page 79), Wall Street and the introduction of closed-end funds played an increasing role in satisfying corporations financing needs (Shleifer (2000)).

Thus, our model may help explain why instances of corporate fraud and overinvestment have seemed to be clustered throughout history - often referred to as *waves*. As capital markets play a central role in satisfying firms' financing needs during such waves, some researchers have attributed waves of corporate fraud to periods of overly optimistic investors, or investor mania, in which managers take advantage of naive investors by overstating the prospects of their firms (e.g., Jensen (2004)). While our theory does not have much to say about such irrationalities and their link to corporate fraud, it suggests that during periods of low required rates of return by investors, disclosures will be less informative. Low costs of raising capital can arise for a number of reasons that include, more liquid financial markets, financial innovations, or low risk premia.

If there is systematic time-variation in risk-premia, then our model predicts that the incidence of fraud and overinvestment will also have a predictive component. In fact, a growing literature emphasizes systematic time-variation in risk-premia (see, e.g., Fama and French (1988)). In particular, there is evidence of cyclicality in risk-premia (Lettau and Ludvigson (2001)). With cyclical risk-premia, our model also delivers the prediction that the likelihood of fraud will be cyclical, complementing similar predictions in Hertzberg (2003) and Povel et al. (2005).

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and among firms with valuable growth options.

However, the asymmetric information foundations of our framework yield a richer set of dynamic predictions on the likelihood of fraud and overinvestment than cyclicality. Arguably, asymmetric information regarding investment opportunities is the greatest when there are new type of investment opportunities; for example, through technological innovations or trading in new markets. Because the likelihood of fraud is positively related to the extent of asymmetric information in equilibrium, our framework suggests that the incidence of fraud and overinvestment would be higher at the onset of new technologies or new trading opportunities. The effect of permanent shocks like technological innovations on fraud distinguishes our analysis from models that view fraud as a cyclical phenomena.

6.3 Managerial Compensation

In equilibrium, the manager enjoys the same expected utility following a report of high productivity as she does following a report of low productivity and is willing to come forward with information that leads to lower levels of investment. The manager is compensated with both wages and private benefits from control following a low report, and is compensated with private benefits from control following a high report. The requirement to reward the manager following disclosures that lead to unfavorable outcomes is common to such adverse selection models.[26] Such rewards are often interpreted as severance pay, and golden parachute (see discussion in Eisfeldt and Rampini (2006)). In the model, managers that are more likely to overstate productivity also receive higher wage compensation following low reports (e.g., when growth opportunities are high).

In addition, our analysis points to an interesting role for performance-contingent compensation contracts for managers of widely held firms, one that has not been emphasized in the literature. We consider adverse selection (without moral hazard), the agent is risk-averse, and the shareholders are risk-neutral. In the standard principal-agent framework, performance-contingent contracts will not be incentive-efficient because random compensation worsens risk-sharing without endowing any incentive benefits. However, such contracts may benefit the *principals* (or shareholders in our model) by relaxing the coordination constraints by influencing their objective function ex post, thereby making their Bayesian-rational investment strategy closer to the ex ante incentive-efficient investment policy.

[26] In Levitt and Snyder (1997), managers are rewarded for coming forward with bad information in order to elicit early warnings, and in Eisfeldt and Rampini (2006), managers are rewarded for disclosing low levels of productivity.

More generally, our framework suggests that fraud aimed to manipulate future investors is more likely to be observed as the control of a corporation becomes less concentrated: a refutable prediction that would be interesting to test in future research. For example, Coffee (2005) attributes differences in firms' propensity to manage earnings, while comparing the U.S. and Europe, to differences in firms' concentration of ownership.

6.4 Communication in Internal and External Capital Markets

While our model has been couched in terms of allocation of capital by *external* capital markets, it has implications for within-firm capital allocation by *internal* capital markets, as well. A fundamental distinction between internal and external capital markets is that total and unconditional control rights are allocated to the capital provider (i.e., the CEO) in internal capital markets, while the capital providers in external markets can not exercise control (in corporations), as emphasized by Berle and Means (1933).

An old line of argument, due to Alchian (1969) and Williamson (1975), is that an internal capital market results in higher quality of information than an external capital market. The literature emphasizes the incentives to produce information as an extension of this argument. In particular, by learning about their organizations, CEO's can implement appropriate value-enhancing actions (unlike other financiers that lack control rights), which in turn improves the decision-making process in internal capital markets (Gertner, Scharfstein and Stein (1994) and Stein (2001)).

But there is also considerable evidence that conglomerates tend to overinvest in bad divisions and underinvest in good ones. For example, Scharfstein (1998) finds that division in high-q industries tend to invest less than their stand-alone industry peers, while Rajan Servaes and Zingales (2000) show that diversified firms tend to allocate more capital, on average, toward low-q segments compared to high-q segments. In a related vein, Gertner, Powers and Scharfstein (2002) find that spin-offs tend to cut investment in low-q industries and increase investment in high-q industries.

These findings raise the natural question: if internal capital markets result in a higher quality of information (cf. Alchian (1969) and Williamson (1975)), why then do they overinvest? Interestingly, our analysis is consistent with both superior information generation and overinvestment by internal capital markets in low productivity units. However, the reasons for the informational advantages in our model are different from those advanced in the literature: in our framework, internal capital markets are more informative because of the ability of CEOs to use their control rights and *credibly* *commit* to an investment response to division managers' strategic disclosures.

To fix ideas, suppose that a CEO of a multi division firm is less informed than a division manager regarding a certain project. While the division manager might have preferences to increase the level of investment in her own division the CEO must elicit this information in order to efficiently invest. As we have discussed above, the optimal mechanism may involve (ex-post) inefficient levels of investment in order to reduce the rents received by the (division) manager. Unlike changing owners, the CEO faces a repeated relationship with the division managers and has an incentive to build a reputation. Such a repeated game may support ex-post inefficient levels of investment executed by the CEO to increase the ex-ante value of the firm. For example, the CEO may build a reputation to underinvest in good projects—as suggested by the second-best contract described in Theorem 2. To the extent that such commitment can be supported in internal capital markets by reputation, the noisy revelation equilibrium is less beneficial and internal capital markets become more informative.

6.5 Communication in Competitive Managerial Labor Markets

In this section we discuss how managerial career concerns in competitive managerial labor markets can lead to noisy revelation and overinvestment, and slow the pace of learning about managerial talent. It turns out that if we interpret "private benefits" of control in terms of career concerns of self-interested managers, then our framework suggests a higher likelihood of fraud—including earnings manipulations by CEOs and window-dressing by money managers—due to efficient labor markets.[27] Empirically, career concerns seem important in the markets for CEO's and money managers. For example, CEO turnover tends to follow poor stock market performance (Coughlan and Schmidt (1985) and Weisbach (1988)) and those that perform poorly are less likely to become outside members on the Boards of Directors of other firms (Gibbons and Murphy (1992)). Similarly, past performance of various types of institutional fund managers influences their fund-raising ability (Lakonishok, Shleifer, Thaler, and Vishny (1991), Sirri and Tufano (1998)). Meanwhile, Holmstrom and Ricart I Costa (1986) and Holmstrom (1998) theoretically examine the implications for capital budgeting and managerial actions when managers are concerned about the effects of firm performance on the labor market's perceptions of their managerial skills.

[27] Lakonishok et al. (1991) show that funds (in particular small) sell poorly performing stocks in a manner that is consistent with a window-dressing strategy, and Gompers and Lerner (1999) provide evidence of grandstanding by Venture Capitalists.

To conjecture about the implications of career concerns for corporate disclosure, it is useful to reinterpret the parameters. When managers and markets learn about managers' type and talented managers are scarce, one would expect talented managers to earn a premium over non-talented managers in equilibrium. Suppose that talent is correlated across periods; and, in the context of our model, more talented managers have a higher probability of the good state occurring and are therefore more likely to be productive. In such an environment, reporting a high signal is beneficial to managers as it alters investor's updated beliefs about the manager's talent. The extent to which a high report will lead to higher future wages for the manager, however, depends on the informativeness of the signal.

In an equilibrium with reporting strategy π_{lh}, let μ_h be the probability that the state is high, given a high signal reported by the manager, i.e., $\mu_h = \frac{\mu}{\mu+(1-\mu)\pi_{lh}} \geq \mu$. We also recall that the probability that the state is high given a low report is zero. Let the manager's future compensation as a function of investors' beliefs z be $\hat{b}(z)$. The manager will prefer to report a high signal over a low signal, as $\hat{b}(\mu_h) - \hat{b}(0) \geq 0$. This leads to a problem that is mathematically equivalent to the one we have analyzed above, as long as $\hat{b}(z)$ is an increasing function - in particular when $\hat{b}(z) = \psi z$. Under this interpretation, the parameter ψ represents the extent to which learning about managerial type is productive in future periods and the results we have discussed follow directly from Theorem 3 and the subsequent analysis.

Interestingly, this reinterpretation of the theory also suggests that career concerns may lead to slower learning about managerial ability, in particular, in times when this information is most valuable. This suggest a possible link between recent changes in the market for CEO's during the last two decades (such as high turnover) and the corresponding increase in fraudulent behavior.

6.6 The Corporate Charter

In this section we discuss how the corporate charter (as a commitment device) can increase firm value by *not* bringing to minimum the firm's cost of capital. The lack of full commitment to arbitrary investment policies in financial markets is the central friction we have explored in this paper, which results in implementation of non-truthful reporting by insiders and subsequent over-investment in equilibrium. While such a remedy involves inefficiencies and is costly to owners, one would expect that mechanisms that facilitate such commitment should have emerged over time. Indeed, one such example is the Corporate Charter. The corporate charter specifies the list of conditions that provides the corporation with the right to exist and operate. Owners in control of the corporation in future subsequent periods then must follow the guide lines put forward in the charter.

Corporate charters exhibit substantial cross sectional differences, especially with respect to the strength of corporate governance (Gompers, Ishii, and Metrick (2003)). For example, while some firms provide guidelines that secure the interests of shareholders (*democratic*), other firms provide more freedom to management (*dictatorship*). *Prima facie*, this type of heterogeneity is puzzling because a common objective of corporate charters is to provide a set of guidelines to secure subsequent efficient operation of the corporation; one would therefore expect corporate charters to uniformly aim towards minimizing firms' cost of capital.

Our model highlights a somewhat surprising advantage for firms to restrict themselves ex-ante to higher costs of capital in the future. That is, firms optimally set guidelines in the corporate charter that *impede* the minimization of the cost of raising capital. To see the main intuition, consider a marginal increase in a firm's cost of capital. The clear disadvantage to owners is that they now need to allocate higher fractions of firm output to their financiers (all else equal). The more subtle advantage, however, is that this assists in mitigating the commitment problem. In particular, when owners are faced with higher costs of capital then insiders are less inclined to overstate firm performance as the implications for investment are dampened. One can make this intuition more precise and show that when the private benefits from control exceed a certain threshold, it will be optimal to voluntarily increase the firms cost of capital. That is, for high enough private benefits of control, a possible substitute for implementing misreporting by insiders is a somewhat "inefficient" corporate charter.

6.7 Equilibrium Under-Reporting

Up to this point, we have focused our attention to the possibility of over-reporting by management. As we mentioned earlier, our approach is primarily motivated by the empirical evidence regarding the misreporting practices of corporations (see, e.g., Burns and Kedia (2004) and Bogle (2005)). However, there is also evidence suggesting that firms sometimes understate earnings (e.g., Burns and Kedia (2004)). The theory presented above indicates that understating performance may increase investment efficiency when investors interpret earnings as signals for future performance. In the following proposition, we provide conditions under which an equilibrium with under-reporting dominates a truth-telling equilibrium and a pooling equilibrium.

We also show that it is more likely that an equilibrium with overstatements will dominate relative to an equilibrium with understatements, provided that the probability of success is smaller than one half. The result is quite intuitive. Overstatements introduce overinvestment in the bad state, while understatements introduce underinvestment in the good state. When the likelihood of the low productivity state is large, the cost of implementing truth-telling is also high, while the cost due to overinvestment is relatively low. Further, it can be shown that when μ approaches zero, an over-reporting equilibrium dominates for all ψ, while there does not exist any ψ for which an under-reporting equilibrium dominates.

Proposition 6 *There exists ψ_1, ψ_2 such that an equilibrium with under-reporting dominates a truth-telling equilibrium and a pooling equilibrium. Moreover, when $\mu < \frac{1}{2}$, $(\psi_1, \psi_2) \subset (\underline{\psi}, \overline{\psi})$, that is, under a wider set of parameters overreporting is optimal. Finally, as $\mu \to 0$, $(\psi_1, \psi_2) \to \emptyset$ and $(\underline{\psi}, \overline{\psi}) \to R_+$.*

7 Summary and Conclusions

Overinvestment in certain firms or sectors, induced by corporate fraud where informed insiders manipulate the beliefs of uninformed investors through exaggerations of economic prospects, has been historically prevalent, and has recently attracted much attention because of some prominent cases. However, reconciling overinvestment and corporate fraud with rational capital markets poses obvious challenges. We provide a new theory of overinvestment and corporate fraud (or equilibrium lying by insiders) based on two important characteristics of modern corporations operating in well-developed financial markets: agency conflicts due to separation of ownership and control and the presence of active takeover markets. For a wide range of conditions, outside shareholders *optimally* suffer a positive probability of fraud in equilibrium, because the lack of investor coordination increases the incentive compensation costs of inducing truthfulness from informed insiders. In equilibrium, shareholders optimally determine the probability of fraud and the extent of overinvestment.

Our analysis indicates that the likelihood of fraud is higher when the cost of external financing is low; it is higher when growth-options become more valuable (as when significantly new technologies are introduced); and, it is higher when management values control more. Moreover, protecting management compensation from downside risk of investment performance increases the likelihood of fraud in equilibrium. These refutable implications of our model appear consistent with historical evidence. Our framework also yields other interesting implications: comparing the likelihood of fraud in internal versus external capital markets, linking the likelihood of fraud to managers' career concerns, and providing a new perspective on the role of corporate charter.

Appendix

Proof of Theorem 1: Fix any contract $C = \{\boldsymbol{\pi}, \mathbf{k}, \mathbf{w}\}$ and suppose that the report is $r \in \{\ell, h\}$. Then, at the information set (C, r), for any subset of investors ('buyout group') $Y \subseteq Z$, a takeover strategy is described by the profile of non-negative valued mappings, $\Phi_Y(C,r) = (V_Y^{'}(C,r), k_Y^{'}(C,r))$. Here, $V_Y^{'}$ is the tender offer, while $k_Y^{'}$ is the investment level following a change of control. Meanwhile, each shareholder $x \in X$, has a response strategy at his information set $(C, r, V_Y^{'})$, represented by the function $\xi(x; C, r, V_Y^{'}) \in \{0, 1\}$, where "0" is the decision to reject the tender offer and "1" denotes the decision to accept. Without loss of generality, shareholders are assumed to accept the offer if indifferent, while buyout groups are assumed not to make an offer if indifferent. The takeover is successful if $\xi(x; C, r, V_Y^{'}) = 1$, for each $x \in X$. A takeover game, $\Gamma(Y, C, r)$, thus requires the specification of the buyout group (Y) and the strategies $(\Phi_Y(C,r), \xi(x; C, r, V^{'}), x \in X)$.

We now define a PBE of $\Gamma(Y, C, r)$. For a given (Φ, ξ), the expected payoffs for the buyout group Y are,

$$\Pi_Y(\Phi, \xi; \mathbf{C}, r) = \begin{cases} \rho(s_h|\mathbf{C}, r)\left[s_h f(k^{'}) - w_r^{+} + w_r^{0}\right] - w_r^{0} - Rk^{'} & \text{if } \xi(x; \mathbf{C}, r, V^{'}) = 1, \forall x \in X \\ 0 & \text{else} \end{cases} \tag{22}$$

And, the expected payoffs to the shareholders are,

$$W(x, \Phi, \xi; \mathbf{C}, r) = \begin{cases} \alpha(x)V^{'} & \text{if } \xi(x; \mathbf{C}, r, V^{'}) = 1, \forall x \in X \\ \alpha(x)V(\mathbf{C}, r) & \text{else} \end{cases} \tag{23}$$

Here, $\alpha(x)$ denotes the fraction of the firm's equity held by shareholder x and $V(C, r)$, defined in (7), is the firm's status quo value at the information set (C, r). Then, (Φ, ξ) is a PBE if, for any Borel measurable $Y \subseteq Z$ and any given (C, r), $\Pi_Y(\Phi, \xi; C, r) \geq \Pi_Y(\hat{\Phi}, \xi; C, r)$, for every $\hat{\Phi} \in R_+^6$, while, $W(x, \Phi, \xi_x, \xi_{-x}; C, r) \geq W(x, \Phi, \hat{\xi}_x, \xi_{-x}; C, r)$, for $\hat{\xi}_x \in \{0, 1\}, \hat{\xi}_x \neq \xi_x$. (Here, ξ_x, ξ_{-x} are the projections of ξ on $\{x\}$ and $X - \{x\}$, respectively.)

Suppose that for any given (C, r), the contracted k_r is not ex post efficient. We then establish that there exists at least one takeover game $\Gamma(Y, C, r)$ with a PBE in which the investment level is ex post efficient. In fact, there are a continuum of such equilibria, indexed by $Y \in B[Z]$, the Borel sigma algebra on Z. Then, choose any $Y \in B[Z]$ and then set, $k_Y^{'}(C, r) = \hat{k}_r^* \in \arg\max_{k' \geq 0} V(C, r; k', w_r)$. Now, put, $\hat{V}_Y^*(C, r) \equiv V(C, r; \hat{k}_r^*, w_r)$. By hypothesis, $k_r \neq \hat{k}_r^*$. Hence, by the definition of $\hat{k}_r^*$, it follows that $\hat{V}_Y^*(C, r) > V(C, r)$. Then, it is easy to check that the strategies, $\hat{\Phi}_Y^*(C, r) = (\hat{V}_Y^*(C, r), \hat{k}_r^*, w)$ and, for each $x \in X$,

$$\xi(x;\mathbf{C},r,V_Y^{'}) = \begin{cases} 1 & \text{if } V_Y^{'} = \hat{V}_Y^{*}(\mathbf{C},r) \\ 0 & \text{else} \end{cases}$$

constitute a PBE. Thus, we have established that as long as the contracted k_r is not ex post efficient, there exists a PBE with a successful takeover by a buyout group that 'resets' the investment to the ex post efficient level following the takeover. In fact, there are a continuum of such equilibria that are unique up to the (identity of) the buyout group (Y).■

Proof of Proposition 1: The optimization problem (13) can be summarized as,

$$\max_{u \geq 0} \left\{\mu(s_h f(k_h) - Rk_h) + (1-\mu)[\pi_{lh}(s_\ell f(k_h) - Rk_h) + (1-\pi_{lh})(s_\ell f(k_\ell) - Rk_\ell - u^\gamma)]\right\}. \quad (24)$$

Differentiating the objective function in (24) (labeled 'OBJ' for convenience) yields,

$$\begin{aligned} \frac{dOBJ}{du} &= (1-\mu)\left[\left(s_\ell - \frac{R}{4}(f(k_h)+f(k_\ell))\right)(f(k_h)-f(k_\ell)) + u^\gamma\right]\frac{\partial \pi}{\partial u} - \gamma u^{\gamma-1}\frac{Ru - \mu\psi(s_h - s_\ell)}{Ru} \\ &= (1-\mu)\left[\left(-\frac{uR}{2\psi}\right)(\frac{2u}{\psi}) + u^\gamma\right]\left[-\frac{\mu\psi(s_h-s_\ell)}{(1-\mu)u^2R}\right] - \gamma u^{\gamma-1}\frac{Ru - \mu\psi(s_h - s_\ell)}{Ru} \end{aligned} \quad (25)$$

Setting (25) equal to zero implies,

$$\left[u^{\gamma-2} - \frac{R}{\psi^2}\right][\mu\psi(s_h - s_\ell)] = \gamma u^{\gamma-2}[\mu\psi(s_h - s_\ell) - Ru]$$

$$\Rightarrow F \equiv \gamma R u^{\gamma-1} - [\mu\psi(s_h - s_\ell)]\left(u^{\gamma-2}[\gamma-1] + \frac{R}{\psi^2}\right) = 0.$$

Now, using the implicit function theorem, from any parameter x,

$$\frac{\partial u}{\partial x} = -\frac{\partial F}{\partial x}/\frac{\partial F}{\partial u}. \quad (26)$$

But, at the optimum,

$$\begin{aligned} \frac{\partial F}{\partial u} &= \gamma(\gamma-1)Ru^{\gamma-2} - (\gamma-1)(\gamma-2)u^{\gamma-3}[\mu\psi(s_h-s_\ell)] \\ &= \frac{\gamma-1}{u}\left(\gamma R u^{\gamma-1} - (\gamma-2)u^{\gamma-2}[\mu\psi(s_h-s_\ell)]\right) \\ &\geq \frac{\gamma-1}{u}\left(\gamma R u^{\gamma-1} - (\gamma-1)u^{\gamma-2}[\mu\psi(s_h-s_\ell)]\right) > 0. \end{aligned}$$

Furthermore, and again at the optimum,

$$\begin{aligned}
\frac{\partial F}{\partial R} &= \gamma u^{\gamma-1} - \frac{1}{\psi^2}\left[\mu\psi(s_h - s_\ell)\right] \propto \gamma R u^{\gamma-1} - \frac{R}{\psi^2}\left[\mu\psi(s_h - s_\ell)\right] > 0 \\
\frac{\partial F}{\partial \psi} &= \left[\mu(s_h - s_\ell)\right]\left(\frac{R}{\psi^2} - u^{\gamma-2}[\gamma - 1]\right) \\
\frac{\partial F}{\partial s_h} &= -u^{\gamma-2}[\gamma - 1]\mu\psi - \frac{R}{\psi^2}\mu\psi < 0.
\end{aligned}$$

The results then follow from (26).∎

Proof of Proposition 2: We can compute,

$$\begin{aligned}
\frac{\partial \pi}{\partial \psi} &= \frac{\partial \psi/u}{\partial \psi}\left(\frac{\mu(s_h - s_\ell)}{(1-\mu)R}\right) > 0 \\
\frac{\partial \pi}{\partial R} &= \frac{\partial uR}{\partial R}\left(-\frac{\mu\psi(s_h - s_\ell)}{(1-\mu)[uR]^2}\right) < 0 \\
\frac{\partial \pi}{\partial s_h} &= \frac{\partial (s_h - s_\ell)/u}{\partial s_h}\left(\frac{\mu\psi}{1-\mu}\right) > 0.
\end{aligned}$$

∎

Proof of Proposition 3: From $\frac{\partial u}{\partial R} < 0$, $k_h - k_l = (\sqrt{k_h} - \sqrt{k_l})(\sqrt{k_h} + \sqrt{k_l}) = \frac{u}{\psi}(\sqrt{k_h} + \sqrt{k_l})$ and the derivatives below the results follow.

$$\begin{aligned}
\frac{\partial k_h}{\partial \psi} &= \frac{\partial k_h}{\partial \pi}\frac{\partial \pi}{\partial \psi} < 0 \\
\frac{\partial k_h}{\partial R} &= 2\sqrt{k_h}\left(-\frac{s_\ell}{R^2} + \frac{1}{\psi}\frac{\partial u}{\partial R}\right) < 0 \\
\frac{\partial k_h}{\partial s_h} &= 2\sqrt{k_h}\left(\frac{1}{\psi}\frac{\partial u}{\partial s_h}\right) > 0.
\end{aligned}$$

∎

Proof Theorem 3: A feasible probability of fraud implied by the first order conditions implies that $uR \in (\overline{u}, \underline{u})$ where $\overline{u} = \frac{\psi(s_h - s_l)}{R}$ and $\underline{u} = \mu\overline{u}$. Next, notice that the (strictly positive) solution to the first order conditions is unique as the second order conditions satisfy,

$$\begin{aligned}\frac{d^2OBJ}{du^2} &= -\gamma(\gamma-1)Ru^{\gamma-2} + u^{\gamma-3}(\gamma-2)[\gamma-1]\left[\mu\psi(s_h-s_l)\right] \\ &\propto -\gamma Ru + (\gamma-2)\left[\mu\psi(s_h-s_l)\right] \\ &\Rightarrow \begin{cases} >0, & u < u^0 \equiv \frac{(\gamma-2)[\mu\psi(s_h-s_l)]}{\gamma R} \\ <0, & u > u^0 \end{cases}\end{aligned}$$

Note that $u^0 < \underline{u} < \overline{u}$ as $\frac{\gamma-2}{\gamma} < 1$. This implies that the solution to the first order conditions, u^*, is feasible if and only if $\left.\frac{dOBJ}{du}\right|_{u=\underline{u}} > 0 > \left.\frac{dOBJ}{du}\right|_{u=\overline{u}}$.

$$\left.\frac{dOBJ}{du}\right|_{u=\overline{u}} = -\left[\frac{\psi(s_h-s_l)}{R}\right]^{\gamma-1} R\left(\gamma-(\gamma-1)\mu\right) + \frac{R}{\psi^2}\left[\mu\psi(s_h-s_l)\right]$$

Thus,

$$\left.\frac{dOBJ}{du}\right|_{u=\overline{u}} < 0 \Leftrightarrow \left(\frac{R^{\gamma-1}}{(s_h-s_l)^{\gamma-2}}\right)\frac{\mu}{\gamma-(\gamma-1)\mu} < \psi^{\gamma}$$

Also,

$$\left.\frac{dOBJ}{du}\right|_{u=\underline{u}} = -\left[\frac{\mu\psi(s_h-s_l)}{R}\right]^{\gamma-1} R\left(\gamma-(\gamma-1)\right) + \frac{R}{\psi^2}\left[\mu\psi(s_h-s_l)\right]$$

Thus,

$$\left.\frac{dOBJ}{du}\right|_{u=\underline{u}} > 0 \Leftrightarrow \left(\frac{R^{\gamma-1}}{(s_h-s_l)^{\gamma-2}}\right)\frac{1}{\mu^{\gamma-2}} > \psi^{\gamma}$$

Thus, the solution is feasible whenever,

$$\psi \in (\underline{\psi}, \overline{\psi}) \equiv \left(\left[\left(\frac{R^{\gamma-1}}{(s_h-s_l)^{\gamma-2}}\right)\frac{\mu}{\gamma-(\gamma-1)\mu}\right]^{1/\gamma}, \left[\left(\frac{R^{\gamma-1}}{(s_h-s_l)^{\gamma-2}}\right)\frac{1}{\mu^{\gamma-2}}\right]^{1/\gamma}\right)$$

This set is non-empty for all $\gamma \geq 2$. Similarly, the interval $(\underline{R}, \overline{R})$ can be defined. ∎

Proof of Corollary 1: We note that there exists a $w_\ell > 0$ that sets $\pi_{\ell h}$ as described in (17) to 0. Hence, under the condition annunciated in Theorem 1, that choice of w_ℓ is dominated by another wage, given which, the manager's best response reporting strategy sets $\pi_{\ell h} < 1$. ∎

Proof of Proposition 4: It follows from optimal ex-post investment that the only wage contingent plan to induce under investment following a high report satisfies $w_h^+ > w_h^0$. Further, it is not optimal for the owners to set $w_h^0 > 0$. It is also not optimal to set $w_\ell^+ > w_\ell^0$, or $w_\ell^0 > 0$ it will lead to underinvestment following a low report or rent extraction by the manager. In the following we derive the sufficient conditions for the optimal contract not to include output contingent wages. As we are interested in deriving a sufficient condition we disregard the utility of the manager from compensation following a high report. This relaxes the incentive compatibility constraint and increases the gains from using output contingent wages as a disciplinary device. Thus, if we find that the use of output contingent wages is not optimal in the problem to follow, it is definitely not optimal in the original problem. Finally, notice that we can disregard the incentive compatibility constraint of the high type manager which will strictly prefer to report truthfully as long as the low type manager is indifferent.

$$
\begin{aligned}
max_{w_h^+} \quad & \mu((1-w_h^+)2\hat{s}_h\sqrt{k_h} - Rk_h) \\
& +(1-\mu)[\pi((1-w_h^+)2s_l\sqrt{k_h} - Rk_h) + (1-\pi)(2s_l\sqrt{k_l} - Rk_l - u^\gamma)] \\
s.t. \quad & u + \psi\sqrt{k_l} = \psi\sqrt{k_h} \\
& \sqrt{k_h} = \frac{(1-w_h^+)(\mu s_h + (1-\mu)s_l)}{(\mu+(1-\mu)\pi)R} \\
& \sqrt{k_l} = \frac{s_l}{R} \\
& \hat{s_h} = \frac{\mu s_h + (1-\mu)s_l}{\mu + (1-\mu)\pi}
\end{aligned}
$$

We can substitute and get,

$$
u = \frac{\psi}{R}\left(\frac{(1-w_h^+)(\mu s_h + (1-\mu)s_l)}{(\mu+(1-\mu)\pi)} - s_l\right)
$$

Thus we can write the objective function,

$$
\begin{aligned}
max_{w_h^+} \quad & \mu\left((1-w_h^+)2s_h\frac{(1-w_h^+)\hat{s_h}}{R} - R\left[\frac{(1-w_h^+)\hat{s_h}}{R}\right]^2\right) \\
& +(1-\mu)(1-\pi)\left(2s_l\frac{s_l}{R} - R\left[\frac{s_l}{R}\right] - \left[\frac{\psi}{R}\left((1-w_h^+)\hat{s_h} - s_l\right)\right]^\gamma\right) \\
& +(1-\mu)\pi\left((1-w_h^+)2s_l\frac{(1-w_h^+)\hat{s_h}}{R} - R\left[\frac{(1-w_h^+)\hat{s_h}}{R}\right]^2\right) \\
= \quad & \\
& (\mu+(1-\mu)\pi)\left(\frac{(1-w_h^+)^2\hat{s_h^2}}{R}\right) \\
& +(1-\mu)(1-\pi)\left(\frac{s_l^2}{R} - \left[\frac{\psi}{R}\left((1-w_h^+)\hat{s_h} - s_l\right)\right]^\gamma\right)
\end{aligned}
$$

We now derive first order conditions for optimality with respect to w_h^+,

$$FOC_{w_h^+} : -2(\mu + (1-\mu)\pi)\left(\frac{(1-w_h^+)\hat{s_h^2}}{R}\right) + (1-\mu)(1-\pi)\gamma\left[\frac{\psi}{R}\left((1-w_h^+)\hat{s_h} - s_l\right)\right]^{\gamma-1}\frac{\psi\hat{s_h}}{R}$$

We will now analyze the above first order condition in order to obtain a condition under which neglecting output contingent wages is without loss of generality. We seek to find conditions under which the above derivative is negative. It is worth noting at this point that we should restrict attention to $w_h^+ \leq 1 - \frac{s_\ell}{\hat{s_h}}$ as no rents are being paid out to the manager at this point and the incentive compatibility constraint applies when investment in the high state is larger than investment in the low state. Thus, it suffices to explore the sign of the above derivative for $w_h^+ \in [0, 1 - \frac{s_\ell}{\hat{s_h}}]$. For a given π and $\gamma > 2$, the FOC is a convex function of w_h^+. Furthermore, the FOC are negative for $w_h^+ = 1 - \frac{s_\ell}{\hat{s_h}}$. Thus, it suffices to explore the derivative at the extreme value $w_h^+ = 0$. For the this case the FOC can be rewritten as,

$$FOC_{w_h^+=0} : -2(\mu + (1-\mu)\pi)\left(\frac{\hat{s_h^2}}{R}\right) + (1-\mu)(1-\pi)\gamma\left[\frac{\psi}{R}\left(\hat{s_h} - s_l\right)\right]^{\gamma-1}\frac{\psi\hat{s_h}}{R}$$

Notice that $FOC_{w_h^+=0}$ is decreasing in π (this is because $\hat{s_h}$ is decreasing in π). Thus, it suffices to verify that the FOC is negative $\pi = 0$.

$$\begin{aligned}
FOC_{w_h^+=0,\pi=0} \quad &: \quad -2\mu\left(\frac{s_h^2}{R}\right) + (1-\mu)\gamma\left[\frac{\psi}{R}\left(s_h - s_l\right)\right]^{\gamma-1}\frac{\psi s_h}{R} \\
&\propto \quad -2\mu\left(\frac{s_h}{R}\right) + (1-\mu)\gamma\left(\frac{\psi}{R}\right)^{\gamma}\left[s_h - s_l\right]^{\gamma-1} \\
&\propto \quad -\frac{2}{\gamma}\frac{\mu s_h}{(1-\mu)\left[s_h - s_l\right]^{\gamma-1}}R^{\gamma-1} + \psi^{\gamma}
\end{aligned}$$

Thus, the use of output contingent wages is not optimal when $\psi < \tilde{\psi}$ where, $\tilde{\psi} \equiv \frac{2}{\gamma}\frac{\mu s_h}{(1-\mu)[s_h - s_l]^{\gamma-1}}R^{\gamma-1}$. ■

Proof of Proposition 5: We first provide conditions under which $\tilde{\psi} \geq \overline{\psi}$,

$$\begin{aligned}
\tilde{\psi} \equiv \frac{2}{\gamma}\frac{\mu s_h}{(1-\mu)\left[s_h - s_l\right]^{\gamma-1}}R^{\gamma-1} \quad &\geq \quad \left(\frac{R^{\gamma-1}}{(s_h - s_l)^{\gamma-2}}\right)\frac{1}{\mu^{\gamma-2}} \equiv \overline{\psi} \\
&\Rightarrow \\
\frac{2}{\gamma}\frac{\mu^{\gamma-1}s_h}{(1-\mu)\left[s_h - s_l\right]} \quad &\geq \quad 1
\end{aligned}$$

It remains to show that there always exists an interval for which a noisy revelation equilibrium without output contingent wages is optimal. Thus, by contradiction, suppose that $\tilde{\psi} \leq \underline{\psi}$,

$$\begin{aligned}
\tilde{\psi} \equiv \frac{2}{\gamma} \frac{\mu s_h}{(1-\mu)\left[s_h - s_l\right]^{\gamma-1}} R^{\gamma-1} &\leq \left(\frac{R^{\gamma-1}}{(s_h - s_l)^{\gamma-2}}\right) \frac{\mu}{\gamma - (\gamma-1)\mu} \equiv \underline{\psi} \\
&\Rightarrow \\
\frac{2}{\gamma} \frac{s_h}{(1-\mu)\left[s_h - s_l\right]} &\leq \frac{1}{\gamma - (\gamma-1)\mu} \\
&\Rightarrow \\
\frac{s_h}{\left[s_h - s_l\right]} &\leq \frac{\gamma(1-\mu)}{\gamma(1-\mu)+\mu} < 1 \\
&\Leftrightarrow
\end{aligned}$$

We can conclude that there always exists an interval in which the equilibrium in characterized by noisy revelation equilibrium without output contingent wages.■

Proof of Proposition 6: The problem can be rewritten as follows where $p \equiv \pi_{hl}$ (while $\pi_{lh} = 0$). Here we also focus on the case without output contingent wages. As before, one could extend the analysis further in this case also.

$$\begin{aligned}
max_u \quad & \mu((1-p)(s_h f(k_h) - Rk_h) + p(s_h f(k_l) - Rk_l - u^{\gamma})) + (1-\mu)(s_l f(k_l) - Rk_l - u^{\gamma}) \\
s.t. \quad & u \equiv u(w) = w^{\frac{1}{\gamma}} \\
& u = \psi(\sqrt{k_h} - \sqrt{k_l}) \\
& k_h = \left(\frac{s_h}{R}\right)^2 \Rightarrow f(k_h) = 2\left(\frac{s_h}{R}\right) \\
& k_l = \left(\frac{s_l(1-\mu) + s_h \mu p}{R((1-\mu)+\mu p)}\right)^2 \Rightarrow f(k_l) = 2\left(\frac{s_l(1-\mu) + s_h \mu p}{R((1-\mu)+\mu p)}\right) \\
& p = \frac{(1-\mu)(\psi(s_h - s_l) - uR)}{\mu u R}
\end{aligned}$$

FOC

$$
\begin{aligned}
\frac{dOBJ}{du} &= \sum_{i\in\{l,h\}} \frac{\partial OBJ}{\partial k_i}\frac{\partial k_i}{\partial u} + \frac{\partial OBJ}{\partial p}\frac{\partial p}{\partial u} + \frac{\partial OBJ}{\partial u} \\
&= \mu[s_h f(k_l) - Rk_l - u^\gamma) - (s_h f(k_h) - Rk_h)]\frac{\partial p}{\partial u} - \gamma u^{\gamma-1}(1-\mu+\mu p) \\
&= \mu[s_h f(k_l) - R\frac{f^2(k_l)}{4} - u^\gamma) - (s_h f(k_h) - R\frac{f^2(k_h)}{4})]\frac{\partial p}{\partial u} - \gamma u^{\gamma-1}\frac{(1-\mu)\psi(s_h-s_l)}{Ru} \\
&= \mu[\frac{R}{4}(f^2(k_h) - f^2(k_l)) - s_h(f(k_h) - f(k_l)) - u^\gamma]\frac{\partial p}{\partial u} - \gamma u^{\gamma-1}\frac{(1-\mu)\psi(s_h-s_l)}{Ru} \\
&= \mu[(\frac{R}{4}(f(k_h) + f(k_l)) - s_h)(f(k_h) - f(k_l)) - u^\gamma]\frac{\partial p}{\partial u} - \gamma u^{\gamma-1}\frac{(1-\mu)\psi(s_h-s_l)}{Ru}
\end{aligned}
$$

Note that,

$$
\begin{aligned}
\frac{R}{4}(f(k_h)+f(k_l)) &= \frac{R}{2}(\sqrt{k_h}+\sqrt{k_l}) = \frac{R}{2}\left(2\sqrt{k_h} - \frac{u}{\psi}\right) = \frac{R}{2}\left(2\frac{s_h}{R} - \frac{u}{\psi}\right) = s_h - \frac{uR}{2\psi} \\
f(k_h) - f(k_l) &= 2(\sqrt{k_h} - \sqrt{k_l}) = 2\frac{u}{\psi} \\
\frac{\partial p}{\partial u} &= -\frac{(1-\mu)\psi(s_h-s_l)}{\mu u^2 R}
\end{aligned}
$$

Thus we have,

$$
\begin{aligned}
\frac{dOBJ}{du} &= \mu[(\frac{R}{4}(f(k_h) + f(k_l)) - s_h)(f(k_h) - f(k_l)) - u^\gamma]\frac{\partial p}{\partial u} - \gamma u^{\gamma-1}\frac{(1-\mu)\psi(s_h-s_l)}{Ru} \\
&= \mu\left[-\frac{u^2R}{\psi^2} - u^\gamma\right]\left[-\frac{(1-\mu)\psi(s_h-s_l)}{\mu u^2 R}\right] - \gamma u^{\gamma-1}\frac{(1-\mu)\psi(s_h-s_l)}{Ru}
\end{aligned}
$$

Thus,

$$
\begin{aligned}
\frac{dOBJ}{du} &= 0 \\
&\Rightarrow (1-\mu)\psi(s_h-s_l)\left(u^{\gamma-2}(1-\gamma) + \frac{R}{\psi^2}\right) = 0 \\
&\Rightarrow u = \left(\frac{R}{\psi^2(\gamma-1)}\right)^{\frac{1}{\gamma-2}}
\end{aligned}
$$

This solution implies that,

$$
p = \frac{1-\mu}{\mu}\left[\frac{\psi(s_h-s_l)}{R\left(\frac{R}{\psi^2(\gamma-1)}\right)^{\frac{1}{\gamma-2}}} - 1\right]
$$

This solution satisfies $p \in (0,1)$ when,

$$\psi^{\gamma} \in \left(\frac{R^{\gamma-1}}{(s_h - s_l)^{\gamma-2}(\gamma-1)}, \frac{R^{\gamma-1}}{[(s_h - s_l)(1-\mu)]^{\gamma-2}(\gamma-1)} \right)$$

■

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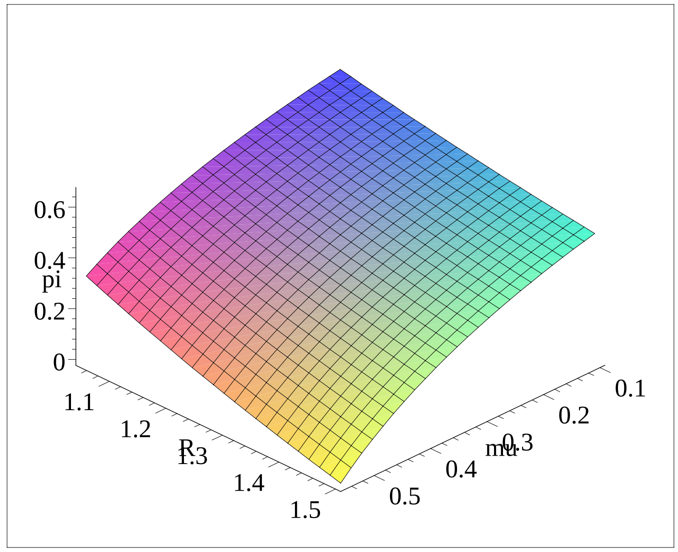

Figure 2

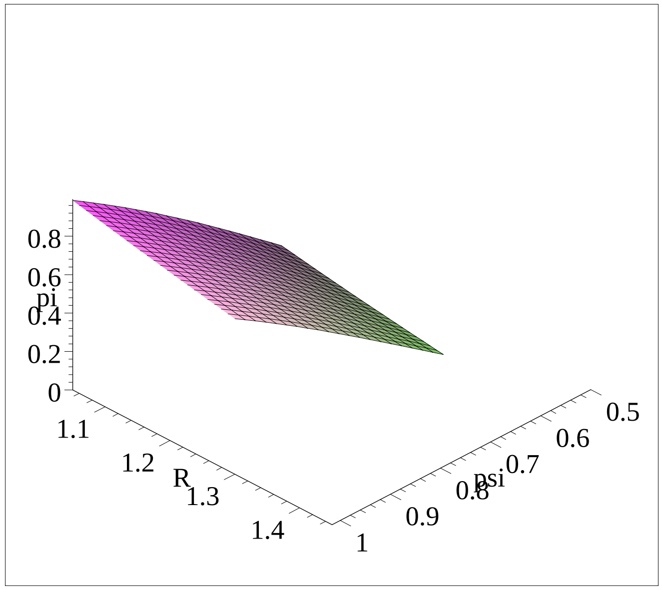

Figure 3

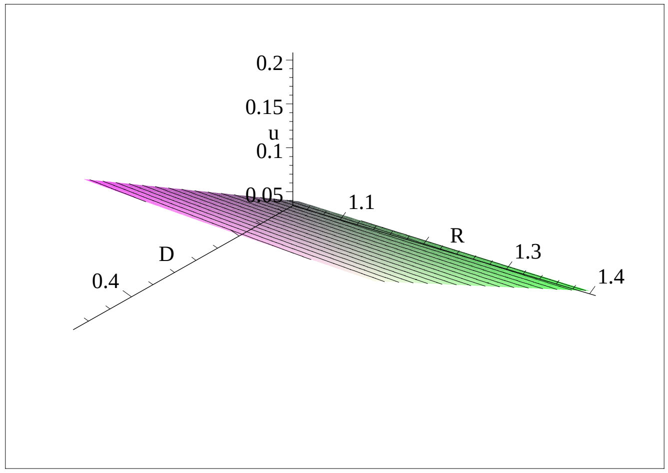

Figure 4

Figure 5
Equilibrium Regions