ENDOGENEITY OF CEO COMPENSATION
AND CORPORATE CRIME

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Abstract. We model costly interactions (contracts) between managers and investors. We suggest that globalization of production and favorable technology shock of the 1990s altered economic environment of manager-investor interactions. These changes exacerbate agency conflict due to the increased managerial gains from ex post reneging, and, simultaneously, decreased costs of managerial reneging. In this case, managerial share of surplus increases at investor expense.

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1. Introduction

Most business leaders aren’t crooks, after all, and they understand that free markets and property rights require the rule of law to function.¹

The occurrence of the terms “corporate fraud,” “accounting scandal,” and “financial crime” in the business sections of major news publications has noticeably increased in 2002, see Table 1, p. 34. The frequency of the terms stubbornly remains at equally high level thereafter, see Table 2, p. 35. Increased frequencies of these words hint at an escalation of the agency problem.

Typically, the involved parties (management and investors) have conflicting interests. Despite the inherent conflict, they are unanimous about the necessity to

improve accounting and disclosure rules, oversight structure, etc. Related questions have been raised in Congress repeatedly, resulting in the Sarbanes-Oxley Act of 2002, and numerous follow-up measures. The act established the Public Company Accounting Oversight Board, legislated enhancements of disclosure and audit practices, and raised fines and criminal penalties for violators.

We relate the ongoing corporate scandals and shaken investor confidence with technology driven changes in the functioning of contractual arrangements. Greenspan, in his July Testimony to Congress (2002) eloquently summarizes the systemic problems of the economy:

“It is not that humans have become any more greedy than in generations past. It is that the avenues to express greed had grown so enormously.”

In our view, this is a non-technical expression of Greenspan’s concern with the principal-agent problem. Our model permits to name “the avenues” (parameters) which affect managerial incentives to engage in legal and accounting violations. We model manager-investor interactions as a principal-agent relations, in which players can engage in costly \textit{ex post} reneging of their \textit{ex ante} contract. We suggest that managerial reneging manifests itself through various forms of managerial misconduct. We propose that recent corporate scandals are rooted in an exogenous (technology driven) shift of parameters characterizing production and contractual environments. We analyze the effects of parameter changes on equilibrium. We argue that recent changes in environment cause an increase in equilibrium managerial reneging. Anecdotic evidence of increased scope of managerial misconduct supports our inferences.

We model manager-investor interactions as a game between parties, which make specific irreversible investments into a project (firm), and thereafter (\textit{ex post}) divide the profit of the joint project according to an endogenously determined ownership allocation (surplus sharing). In such environments, the players have \textit{ex post} incentives of reneging \textit{ex ante} ownership allocation. In our model, \textit{ex post}, players can unilaterally reneg on \textit{ex ante} contact at a cost. Player reneging costs are exogenous, increasing and concave in the magnitude of the requested adjustment of the \textit{ex ante} contract: the higher this magnitude, the higher the reneging expenses. We view reneging costs as characterizing contractual institutions, with more advanced institutions having higher costs. Ceteris paribus, higher costs create disincentives for
player reneging by lowering their expected net gains from reneging. Hence higher reneging costs make player \textit{ex ante} property rights are more secure, and investment incentives – less distorted. We show that higher reneging costs lead to lower equilibrium expenses on \textit{ex post} reneging.

The study of the manager-investor conflict and its effects on corporate performance was originated by Berle and Means (1932). The literature has been advanced by Jensen and Meckling (1976), who established a connection between ownership structure and corporate incentives. Modern contract theory literature addresses the agency conflict in different economic environments. This literature aims to resolve the agency problem stemming from separation of ownership (investor) and control (manager). It is concerned with maximizing investor returns (or social surplus) in specific environments, see reviews by Holmstrom and Tirole (1989), and a comprehensive coverage in Laffont and Martimort (2002). For a contract theory perspective on the issues of corporate governance, see Tirole (2001).

The corporate governance literature that addresses macro-level implications was surveyed by Shleifer and Vishny (1997), and La Porta et. al. (2000). They conclude that legal protection of investors and concentration of ownership are complementary approaches to governance, but do not provide theoretical foundations for the conclusion. We address the question of micro-foundations, and achieve results agreeable with their inferences. Our model is consistent with the stylized fact that improved investor and management legal protection is favorable for investment incentives. We prove that investment incentives improve with higher reneging costs, which we view as reflecting more advanced contractual institutions.

Only a fraction of agency literature takes Demsetz’s (1983) perspective of endogenous ownership rights. The Demsetz and Lehn (1985) paper can be considered a starting point of empirical investigations of ownership endogeneity. Their framework was extended by Himmelberg et. al. (1999), who demonstrate that both managerial ownership and performance are endogenously determined by exogenous (and only partly observed) changes in the firm’s contracting environment. Palia (2001), builds

\footnote{Tirole (1999) review provides more technically demanding and open-ended perspective with suggestive directions for future research.}

\footnote{The literature bearing on the principal-agent problem is far too extensive for reviewing, or even listing it here. For recent developments see Review of Economic Studies, (1999), Vol. 66, Issue I. Numerous references to the literature will be found throughout the paper though we make no claim to completeness.}
on this literature. His paper compellingly demonstrates that CEO compensation is indeed endogenous. Ownership endogeneity implies that differences in ownership structure should not affect firm value if production technology and contractual environment are controlled. Our model gives theoretical foundations for these findings, as our game yields endogenous surplus division between management and investors.

The folklore view of financial scholars on managerial misconduct is surprisingly uniform. According to this view, management always cheats investors (and always will), whereas the promulgation of these cheatings by newspapers is sensation driven. Like natural disasters, such as hurricanes and earthquakes, managerial misconduct happens regularly, and makes its way to the headlines. Consequently, the current situation is a minor statistical aberration, and should not be taken for an indication of systemic problems. We challenge this prevailing view, which discounts the anecdotal evidence of increased managerial cheating as a minor deviation of no theoretical importance. Indeed, we explain the current evidence by technology driven shift in production and contractual environments.

Let us informally present the dynamics of manager-investor interactions implied by the folklore view. The management continuously looks for holes in the contractual system to exploit and enrich itself. Similarly, the investors continuously monitor these self-serving managerial activities, aiming to expose and fix the holes. The system is self-tuning. If the management finds a hole and acquires substantial extra wealth, investors experience a decrease in their wealth, which prompts them to increase the efforts of searching for the hole, and fixing it. To sum up, the recurrence of managerial misconduct stays, only specific misdemeanors change with time.

We completely agree that managerial misconduct is a recurring phenomenon. We are interested in determinants of frequency and scope of such a misconduct. We suggest that recently increased frequency and scope of corporate crime is real, and reflects an increase of managerial equilibrium share of surplus at the investors' expense.

We advocate that favorable technology shock of the 1990s and globalization of industrial production created ample holes in contractual system: i.e., the possibilities to exploit its imperfections. The present-day contractual environment alters relative managerial and investor costs of ex post reneging advantageously for management.

\footnote{Palia (2001) works with panel data, and uses the fixed effects methodology to control for firm specific effects. He has separate equations for CEO compensation and firm value (using Tobin’s Q as a proxy), and simultaneously estimates this system of equations.}
We identify five factors contributing to an increase of managerial reneging: advancement of production technology, decrease of investor outside option, increase of CEO outside option, and two factors related with the contractual system. The latter factors reflect the changes of contractual capabilities, induced by a favorable technology shock of the 1990s and globalization of industrial production, both of which turned out to be unfavorable for ownership security.

Firstly, internationalization of production makes it more costly to prove a breach of contract, and, once it is proven, to receive a compensation. The latter statement is an expression of the fact that legal systems of advanced economies (U.S., Germany, Japan, etc.) are more mature than the international legal system, which features cross-country contractual incompatibilities, worsened by weak international enforcement mechanisms, see Staiger (1995), La Porta et. al. (1999), and Carpio et. al. (2001) for review. Secondly, technological changes alter information processing, and amplify CEOs’ informational advantage over investors. Simultaneously, the globalization of production and advancement of the financial system give the CEOs new means to utilize their informational advantage, thus, exacerbating the agency conflict. Overall, these factors affect both parties, CEO and investor, albeit differently. These factors increase in managerial reneging advantage over investors, which weakens the contractual system.

To summarize our contribution, we identify the factors affecting the firm’s contractual environment, and formulate testable predictions, connecting production technology and ownership structure with firm value and performance. From our model, the managerial ownership share increases with weaker contractual institutions, more advanced production technology, and when managerial reneging costs decrease relative to the investor ones. Consistent with data, our results predict lower aggregate profits when contractual institutions are weak (La Porta et. al. (1999)), or investor protection is low (Daines (2001)), and an increase in the managerial ownership share when technology is more advanced (Holderness et. al. (1999)). We suggest that our model provides micro-foundations for the empirical evidence of endogenous ownership, and gives refutable predictions, which fit existing data.

The paper is organized as follows. In Section 2 a stage game is presented and its equilibrium properties outlined. In Sections 3 and 4, comparative analysis is provided, with Section 3 focusing on parameters of contractual institutions, and
Section 4 – on technology. The discussion and the concluding remark are presented in Section 5. Proofs and technical details are relegated to Appendices.

2. Model

We start with a game between two players, a CEO (manager) and an investor (owner), and denote the corresponding game by $\Gamma$. The game $\Gamma$ is a game of complete information with the following order of moves. First, one of the players proposes a contract which allocates player ownership shares for a jointly implemented project; i.e., it allocates the project’s surplus share $x \in [0, 1]$ to the CEO, and $(1 - x)$ to the investor. We consider games with $x$ chosen by either player, and let $\Gamma^1$ denote the game in which the CEO chooses $x$, and $\Gamma^2$ the game in which the investor chooses $x$. In addition, we consider a benchmark – the game $\Gamma^p$ – in which ex ante ownership allocation is chosen by a social planner, whose objective is to maximize total society surplus, which equals player surplus and their reneging costs. To simplify the notation we drop the subscript $i$ when possible.

Second, the CEO and the investor simultaneously and independently choose to dedicate to the joint project irreversible effort $q_1$ and investment $q_2$, which are expressed in monetary terms. Each player has an outside option, the CEO – an alternative job with a fixed return $\omega$ to his effort, and the investor – an alternative project with a fixed investment return $\xi$. We let the joint CEO-investor project’s net value $S(q)$ be equal to

$$S(q) = \mu P(F(q)) - \omega q_1 - \xi q_2, \quad q = (q_1, q_2), \quad F(q) = \min(q_1, q_2),$$  \hspace{1cm} (1)

where a constant $\mu > 0$ characterizes technology, and $\mu P(F(q))$ is the probability of successful operation of the project (for example, the probability of R&D success), when player actions are $q$. We call the actions $q_1$ and $q_2$ “investments.” We borrowed this production function and its interpretation from Varian (2002), who refers to it as the prototype case of weakest link. In this case, the value of the project depends on the minimum investment (Leontief production function).

Third, after the project has been undertaken, each player can unilaterally change the ex ante contract (i.e., renege) – with the respective actions denoted by $r$ and $s$ – through costly ex post reneging. The players choose $r$ and $s$ simultaneously and independently. Their ex post ownership shares are respectively equal to $t$ and $(1 - t)$.

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$^5$See Kremer (1993) for demonstration of wide applicability of this production function.
for the CEO and the investor, where \( t \) is defined as:

\[
t = x + r - s.
\]

We call a player’s ability to alter his share “reneging,” and his expenses on modifying ownership shares reneging costs, emphasizing the direct player actions to alter the shares. The word reneging is somewhat narrow. Our definition of reneging costs includes any expenses on activities intended to modify player surplus shares. Reneging expenses include legal, political, bureaucratic, and, possibly, penalty costs for breach of contract. From our definition, reneging expenses and to \textit{ex post} contractual expenses (i.e., transaction costs) are synonyms.

Each player, the CEO and the investor, maximizes his net gain from the project, denoted by \( W(a) \) and \( \Pi(a) \), respectively, and equal to the value of his ownership share net of reneging expenses and the outside option return:

\[
W(a) = t\Phi(q) - \beta B(r) - \omega q_1, \quad a = (x, r, s, q), \quad \beta \geq 0, \quad \omega \geq 0, \quad (2)
\]

\[
\Pi(a) = (1-t)\Phi(q) - \gamma B(s) - \xi q_2, \quad \Phi(q) = \mu P(F(q)), \quad \gamma \geq 0, \quad \xi \geq 0, \quad (3)
\]

where we assume \( \max(\beta, \gamma) > 0 \) and \( \max(\omega, \xi) > 0 \). The vector \( a \in A \), where \( A \) is the set of action profiles of the game \( \Gamma \). The constants \( \beta \) and \( \gamma \) reflect that player reneging costs. In our game, \textit{ex post} reneging is a mechanism by which the players change their \textit{ex ante} contract, and we interpret their reneging costs \( \beta B(r) \) and \( \gamma B(s) \) as their \textit{ex post} transaction (i.e., contractual) costs.

Consider CEO interactions with the board of directors. Then, the constants \( \beta \) and \( \gamma \) proxy player costs of \textit{ex post} contractual adjustment. The data indicates that CEO reneging costs become relatively more favorable with the length of his tenure, (i.e., \( \beta \) decreases and/or \( \gamma \) increases, which we interpret as an indication that in the long-run, \( \beta \) and \( \gamma \) are not constants, but endogenously determined parameters); and CEO reneging costs increase with frequency of board meetings, see Hermelin and Weisbach (1988), (1991). These results reflect a growing consensus of the literature that endogeneity of ownership allocation is a focal feature of management-investor interactions.\(^6\)

From equation (1), neither player can implement the project alone. We assume that the function \( \mu P'(F) \) evaluated at zero exceeds the outside options.\(^7\)

\(^6\)Reviewed by Hermelin and Weisbach (2003).

\(^7\)This implies absent reneging, players positively invest into the joint project \( \forall t \in (0, 1) \).
function $P$ is continuous, concave and three times continuously differentiable for $F \in (0, \infty)$; the function $B$ is continuous, convex and three times continuously differentiable for $v \in (0, \infty)$, and is zero for $v < 0$:

$$P'(F) > 0, P''(F) < 0, P'''(F) < 0 : \forall F \in (0, \infty), \lim_{F \to 0} \mu P'(F) > \min(\omega, \xi),$$

$$B'(v) > 0, B''(v) > 0, B'''(v) \leq 0 : \forall v \in (0, \infty), \quad B(v) \equiv 0 : \forall v < 0.$$  

The condition $B(v) \equiv 0$ for $v < 0$ means that each player can reduce his ownership share at no cost, which entails zero fixed cost of reneging. To ease presenting the proofs, we impose $P''' \leq 0$ and $B''' \leq 0$, and $\lim_{v \to 0} B'(v) = 0$.

For the given functions $P$ and $B$, the game $\Gamma^i$ has 5 parameters: $\mu, \beta, \gamma$ and $\xi, \omega$:

$$\Gamma^i = \Gamma^i(\mathbf{o}), \text{ where } \mathbf{o} = (\mu, \beta, \gamma, \xi, \omega),$$

and $i = 1, 2$ or $p$ correspond to CEO, investor or social planner choosing an ex ante contract (i.e., $x$). To sum up, the game $\Gamma^i$ has three stages. First, player $i$ chooses $x$. Second, the players simultaneously and independently choose $q_1$ and $q_2$. Third, after investments are sunk, the players simultaneously and independently choose $r$ and $s$, and the project surplus is divided between the CEO and investor, with respective ownership shares $t$ and $(1 - t)$.

We assume that players coordinate on Pareto efficient subgame perfect Nash equilibrium, and use such an equilibrium as the solution concept for our game. We denote equilibrium outcomes and payoffs by the superscript $'*$.'

**Definition 1.** Let $\hat{\Gamma}^i$ denote the game $\Gamma^i$, in which ex ante and ex post contracts are restricted to be identical: $x \equiv t$.\(^9\)

In the game $\hat{\Gamma}^i$ the players are committed to their ex ante contract. The game $\hat{\Gamma}^i$ is identical to the game $\Gamma^i$, in which high sunk costs of reneging make non-reneging optimal for the players.

**Theorem 1.** An equilibrium of the game $\hat{\Gamma}^i$ exists, and is unique.

**Proof.** See Appendix. \(\square\)

\(^8\)Nonzero fixed-cost of reneging is allowed in Schwartz (2005).

\(^9\)For example, non-reneging is optimal, when sunk cost of reneging is equal to (or exceeds) the project value in the game $\Gamma^p$ with $\omega$ and $\xi$ approaching zero.
Let \( {^\hat{\cdot}} \) denote equilibrium outcomes and payoffs in the games \( {^\hat{\Gamma}}^i \), with \( i = 1, 2 \) or \( p \). From equation (1) and player objectives (equations (2) and (3)), in any equilibrium \( q_1 = q_2 \). We will interpret the statement \( q^a < q^b \) component-wise.

For the intuition behind the proof of Theorem 1, notice that in the subgame \( {^\hat{\Gamma}}^i(x) \), which starts after CEO ex ante share \( x \), best responses \( q_1 \) and \( q_2 \) are unique. We show that for each \( i \), surplus sharing, at which player \( i \) receives his highest payoff is unique. Clearly, the equilibrium of the game \( {^\hat{\Gamma}}^i \) depends on the identity of the player who chooses surplus sharing. Naturally, the equilibrium payoff is higher for the player who chooses \( x \).

**Proposition 1.** In the equilibria of the games \( {^\hat{\Gamma}}^i=1,2 \) investment distortion is smaller when ownership contract is proposed by the player with a higher outside option:

\[
{^\hat{q}}^1 \leq {^\hat{q}}^2 \quad \text{if} \quad \omega \leq \xi.
\]

**Proof.** See Appendix. \( \square \)

Proposition 1 relates the size of investment distortion with player outside options, see Figure 1, p. 36. From Proposition 1 and Theorem 1, equilibrium of the game \( {^\hat{\Gamma}}^i \) with \( i = 1, 2 \) is efficient, only when the outside option of the player not choosing ex ante surplus sharing is zero. The result is intuitive: to make the player with a higher outside option invest the same amount as the player with a lower outside option invests, additional ‘carrots’ are needed. His choice of ex ante option provides such a carrot. When the player with a higher outside option chooses ex ante contract, surplus sharing is favorable for him, which improves efficiency.

Next, we study the game \( \Gamma \). Without loss of generality, and reflective of the current managerial fraud and accounting violations we impose

\[
\beta \leq \gamma,
\]

which implies that reneging is cheaper for the CEO than for the investor. The following theorem establishes the existence of equilibrium in the game \( \Gamma \).

**Theorem 2.** An equilibrium of the game \( \Gamma^i \) exists, and is unique. Each player investment and surplus are bounded from above by his equilibrium surplus in \( {^\hat{\Gamma}}^i \). Player aggregate surplus is strictly lower in the game \( \Gamma^i \) than in \( {^\hat{\Gamma}}^i \).

**Proof.** See Appendix. \( \square \)
To prove Theorem 2, we show that there exist at most two *ex ante* CEO share(s), such that player cumulative payoff in equilibria of the subgames of the game $\Gamma$ that start at these shares, is maximal. Let $\Gamma_x$ denote the subgame of the game $\Gamma$ that starts at *ex ante* share $x$.

**Remark 1.** There exists a unique investment, and two CEO shares, $x^{h_2}$ and $x^{h_1}$, such that net project value in the equilibria of the games $\Gamma$ that start at these shares is the highest among $\Gamma_x$:

$$q^{h_s} < q^{p_s} = \hat{q}^p, \quad t^{h_2s} \leq t^{p_s} = \hat{t}^p \leq t^{h_1s} \quad \text{and} \quad S^{p_s} < S^{h_s}.$$

**Proof.** Follows from the proofs of Theorems 1 and 2. \qed

From Remark 1, the firm value peaks twice (see Figure 2, p. 37) at in the equilibria of the game $\Gamma_x^{h_2}$ and $\Gamma_x^{h_1}$, in which player total surplus is identical, but its distribution between the players differs. Player maximum aggregate surplus in the equilibrium in $\Gamma^p$ is strictly lower than in $\hat{\Gamma}^p$, although equilibrium investments are equal in both games. While in the game $\hat{\Gamma}^p$ player cumulative surplus is the highest among all games $\hat{\Gamma}_x$, player cumulative surplus in the games $\Gamma_x^{h_2}$ and $\Gamma_x^{h_1}$ is higher than in $\Gamma^p$.

Our main interest is *ex post* contractual efficiency, and investment suboptimality driven by *ex post* reneging. In other words, we only superficially address how *ex ante* contract sets CEO compensation. We do not tackle incentives misalignment caused by *ex ante* contract, which assigns possibly socially suboptimal, but mutually agreeable, surplus sharing between the CEO and the investor. Our focus is managerial misconduct, modeled as CEO reneging, and inefficiencies arising from *ex post* adjustment of surplus sharing stipulated by *ex ante* contract.

Indeed, our treatment of *ex ante* efficiency is primitive: clearly, the games $\Gamma^i$ with $i = 1, 2$ are extremes, each game gives full advantage to the player who proposes an *ex ante* contract. One would expect that in the game where *ex ante* contract is determined via players’ Nash bargaining, investment suboptimality is smaller than when *ex ante* contract is imposed unilaterally.

**Proposition 2.** Each game $\Gamma^i$ has a unique equilibrium, $x^{i*} \leq t^{i*}$, and the inequality is strict if $\beta \neq \gamma$. In the game $\Gamma^p$

$$q^{p*} = \hat{q}^p, \quad p^{p*} = \hat{p}^p,$$
and in the games $\Gamma_{i=1,2}$ we have:

$$t_{2*} \leq \hat{t}_2, \quad \bar{t}_1 \leq \bar{t}_1^*, \quad q_{1*}^i \leq \hat{q}_1^i \quad \text{and if} \quad \omega \leq \xi \quad q_{1*}^1 \leq q_{1*}^2.$$ 

**Proof.** Follows from the proofs of Theorems 1 and 2. \qed

Proposition 2 establishes that for $\beta \neq \gamma$, in the game $\Gamma^i$, the CEO’s ex post equilibrium share is higher than the ex ante one. This occurs because reneging is cheaper for the CEO, and for any fixed investment, his optimal share adjustment is higher than for the investor. From Proposition 2, investment is higher in the game where ex ante sharing is chosen by the player with higher outside option and reneging constant. Indeed, the outside option part of the result mimics the result of Remark 1, and higher reneging constant leads to lower equilibrium spending on reneging, which reduces investment distortion in the game $\bar{\Gamma}^2$ relative to the distortion in the game $\Gamma^1$. From Proposition 2 in the equilibria of the games $\Gamma^i$, CEO ex post share exceeds his ex ante share, see Figures 3 - 4, pp. 38 - 39.

Investment distortions in the games $\Gamma^i$ can be divided into two groups, technological and contractual. The former group is rooted in technology of production, investment market and property allocation imperfections. In out setup market and technology structure are reflected by player outside options and production function, and ownership structure by the choice ownership allocation. Resulting investment distortions mimic the distortions of the game $\hat{\Gamma}^i$.

We focus on the latter group of distortions, which stem from contractual imperfections. These distortions are driven by player ex post reneging, and manifest by two effects. The first one is underinvestment due to divergence of ex ante and ex post incentives to invest ($x^* \neq t^*$), and the second one results from player concern by the magnitude of their reneging expenses, which leads to different optimal surplus sharing in the game $\Gamma$ and $\hat{\Gamma}$.

**Remark 2.** For any fixed $q$, player optimal reneging expenses are unique, and decreasing with the player’s reneging constant.

**Proof.** Follows from the proof of Theorem 2. \qed

From Remark 2 in any equilibrium, reneging expenses are higher for the CEO than for the investor. Theorem 2, Propositions 1 and 2 and Remark 2 permit us to investigate how the equilibria of the games $\Gamma^i$ change with parameters. As we suggest below, the observed increase of CEO reneging follows from the present-day
technological and contractual parameters. Although player costs of choosing share adjustment of a fixed size are increasing with $\beta$ and $\gamma$, from Remark 2, for more advanced contractual system (i.e. with higher $\beta$ or $\gamma$) player equilibrium costs of reneging decrease.

If production globalization and favorable technology shock of 1990s were indeed favorable for management, and increased its advantage in \textit{ex post} reneging, our model predicts an increase of CEO surplus share. In the next two sections we address what parameter changes can lead to such an increase.

3. Effects of Contractual Institutions

As we suggested, player adjustment costs proxy their contractual costs, or more precisely, \textit{ex post} contractual costs, such as legal or settlement resolution expenses, or fines and penalty costs, etc. Clearly, these costs are dependant on contractual environment, and on relative player capacity to function in this environment. The difference of $\beta$ and $\gamma$ reflect player asymmetries with respect to contractual system. These asymmetries could be a results of asymmetric information between CEO and investors, their relative ability to process this information; and financial, legal and organizational resources at their disposal.

Since technology and contractual system are interdependent, exogenous technological shifts are likely to affect the parameters $\beta$ and $\gamma$ as well. While the effects of technological shock of the 1990s on corporate production and organizational choices is extensively addressed by the literature, effects of this technological shock on contractual system, and through that on managerial incentives, are largely ignored. In general, it is ad hoc to presume identical effect of technological changes on different contractual parties, and in face of currently persistent anecdotal evidence of managerial misconduct, this presumption is likely violated. To simplify the exposition, we focus on the game $\Gamma^1$, and drop the superscript 1, thus denoting it by $\Gamma$.

Proposition 3. If the games $\Gamma$ differ in $\beta$ only, the game with a higher $\beta$ Pareto dominates. The CEO’s share is lower, and project value higher the game with a higher $\beta$.

\textit{Proof.} See Appendix.

From Proposition 3, an increase in $\beta$ makes both players better off. Moreover, the CEO is better off despite the fact that his equilibrium share decreases with
\( \beta \). Proposition 3 is in tune with the findings of Daines (2001), whose evidence is consistent with the theory that Delaware corporate law improves firm value. Using the firm’s \( Q \) as an estimate of firm value, he finds that Delaware firms are worth significantly more than similar firms incorporated elsewhere. Daines suggests that state competition to sell corporate charters and legal rules produces a winning state, Delaware, whose law appears to be more valuable than that of other states. He argues that investor willingness to pay more for Delaware firms and Delaware’s increasing market share are inconsistent with claims that state corporate law is uniform or trivial.

**Proposition 4.** Let two games \( \Gamma^p \) have equal sum of reneging constants; then, reneging expenses are higher in the equilibrium of the game with a higher disparity between reneging constants.

*Proof.* See Appendix. \( \square \)

We view constants \( \beta \) and \( \gamma \) as characteristics of contractual system, one could interpret an increase disparity between reneging constants \( \beta \) and \( \gamma \) as increased informational asymmetry or increased disparity of enforcement costs of the players. The intuition of Propositions 3 and 4 can be used to evaluate the effects of new rules and regulations of contractual system on investment incentives. Below we apply our reasoning to address Regulation Fair Disclosure (Reg FD) (2000) and executive board regulation.

From Propositions 3 and 4, with increase of disparity between CEO and investor reneging constants (i.e., increase of the gap between \( \beta \) and \( \gamma \)), the wedge of \( ex \ ante \) and \( ex \ post \) surplus shares, and thus, the wedge between \( ex \ ante \) and \( ex \ post \) incentives increases. Thus, corporations for which this wedge is high are most prone to managerial violations. Disparity of reneging constants reflect player differences, to be concrete, we focus on player information processing. Information is an important domain of player differences, and we interpret player disparity of reneging constants as reflection of their differences in information processing. Below we discuss refutable applications of our model. That is, we formulate two features of corporations where managerial misconduct is likely.

This paper focuses on hold-up driven by \( ex \ post \) reneging advantage of the CEO. Thus, we take for granted that \( \gamma \) exceeds \( \beta \). From the aforementioned arguments, the statement continues to hold in a broader context of monitoring. From our
results, imposing more constraints on management, not executive board enhances efficiency. Clearly, if $\beta$ exceeds $\gamma$, *ex post* advantage is on investor side, but practical importance of such contexts is questionable.

We expect CEO informational advantage be higher for corporations with more diverse lines of business, in terms of (i) technology and (ii) location. In such corporations, investor monitoring is cumbersome as it involves processing high volumes of information, which differs by its origin and quality. For management, such heterogeneous information is relatively easier to manipulate than homogeneous information, and evaluating such information is harder for the investors. Albeit these informational asymmetries are highly predictable, rank-and-file individual investors have virtually no means of mitigating managerial informational advantage. Even for investors most capable of mitigating informational disadvantages (large scale professional investors, or institutional investors), resolving information asymmetry with management is costly.

Bailey et al. (2003) analyze the stock market reaction and changes in information flow due to the adoption of Regulation Fair Disclosure (Reg FD) (2000), and conclude that Reg FD failed to generate an improvement in information quality. This inference is in line with our results. Indeed, by its goal and design Reg FD does not benefit the investors with already superior information. From our analysis, it is exactly these investors who have the highest efficiency in dealing with global corporations. Reg FD has not been tailored to target the corporations with high managerial informational advantage. Thus, Reg FD does not address the above described effects of technology driven changes on contractual system.

Our analysis indicates that recommendations of financial industry about corporate disclosure regulations should be taken seriously, because it is exactly financial industry, which plays the role of the most informed investor (or investor with the lowest $\gamma$). From Propositions 3 and 4 managerial incentives are the least distorted with the most informed investor.

Our model is applicable to another heavily debated question: regulation of executive boards. Clearly, the operation of executive board affects managerial choices and managerial compensation. While Hermelin and Weisbach (2003) argue that formal theories about board of directors as economic institution are scarce, they suggest that substantive empirical literature permits to develop a “strong intuitive

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sense of the problems facing boards.” The literature, which analyzes the connection of CEO compensation with firm performance and value, strongly confirms that firm value is endogenously determined by its environment (market, contractual, technological, etc.). The following groups of variables are usually included, when the determinants of CEO compensation are investigated: CEO characteristics, firm characteristics (technological and financial), risk level, and the variables affecting interactions of management and the board. The latter group includes the length of CEO tenure, the number of board members, frequency of their meetings, etc. The conclusion of this literature is that board composition and its way of operating are endogenous.

In line with empirical literature, a number of theoretical models suggest that the imposition of restrictions on executive board does not appear a promising venue for improving efficiency. While restrictions on executive board might be justified by improved protection of small investors, the efficiency connotations are unclear. There is an inherent conflict between tougher and more independent boards, and optimal CEO effort. In Hermalin (2004), such boards lead to higher CEO compensation. In our model, increased board diligence may be desirable on efficiency grounds, but as in Hermalin, it leads to higher CEO compensation.

4. Comparative Analysis

Next, we investigate how parameters of the game affect its equilibrium. We interpret $\mu$ as a characteristic of technology. Higher constants $\mu$, $\xi$, or $\omega$ imply, respectively, more advanced technology, or higher investor or CEO outside option. We compare the equilibria of the games $\Gamma$ which differ by technologies or outside options.

Proposition 5. If the games $\Gamma$ differ in $\mu$ only, in equilibrium, the CEO’s share and project value are higher, and investments lower in the game with a higher $\mu$.

Proof. Analogous to Proposition 3. $\square$

Proposition 5 is in tune with data. Consider, for example, the technological advancement of the 1990’s: the inferences of Proposition 5 are robustly supported by corporate profits and stock market data, and, clearly, by CEO compensation data, see Holderness (1999).
Proposition 5 implies that with technology advancement the equilibrium project value, the CEO’s share, and reneging expenses increase. From Proposition 5, reneging expenses increase as technology improves, so does the surplus loss from player imperfect commitment to ex ante contract. Therefore, the importance of contracts increases with technology advancement. To mitigate this increase of reneging expenses, technology improvement should be accompanied by the improvement of contractual institutions. We suggest that the current corporate scandals reflect the necessity to strengthen contractual institutions.

**Proposition 6.** If the games $\Gamma$ differ in $\omega$ only, in equilibrium of the game with a lower $\omega$, investments are higher and the CEO’s share lower.

*Proof.* Analogous to Proposition 3. \qed

From Proposition 6, lower CEO’s outside option makes higher effort optimal for him. Thus, when the CEO’s outside option decreases, equilibrium investment increases, which leads to higher reneging expenses of both players. Let us instrument the CEO’s outside option $\omega$ by the level of executive compensation. This level has dramatically increased during the 20th century. Thus, Proposition 6 permits to rationalize Holderness et. al. (1999) empirical observation of a raise in managerial ownership from 13 percent for the universe of exchange-listed corporations in 1935 (the earliest year for which such data exist) to 21 percent in 1995.

Production function given by equation (1) is a convenient normalization, which implies that equal quantities of CEO and investor inputs are needed for the joint project. But our model easily adopts to production functions differing in relative importance of player inputs via renormalizing one of the inputs to make production function match equation (1). To renormalize, one needs to adjust one outside option only. For example, let ‘real’ production function be such that a unit of investor input has to be matched with $\alpha$ units of CEO input. Then, one can analyze the renormalized model, in which CEO outside option is $\alpha$ times his ‘real’ outside option. This logic permits to interpret the 20th century trend of increased CEO compensation as reflection of increased importance of CEO actions for production (i.e., an increase of $\alpha$).

**Proposition 7.** If the games $\Gamma$ differ in $\xi$ only, in equilibrium of the game with a lower $\xi$, investments and the CEO’s share are higher.
Proof. Analogous to Proposition 3.

In general, data provides that investor outside options decrease in recessions. Thus, from Propositions 6 and 7, in recessions, when “worthy” projects are scarce, investment in the actually undertaken projects increases, which causes an increase in player reneging expenses. Interestingly, from Propositions 6 and 7, a lower outside option of one of the players not only benefits the other player, but also makes the equilibrium project value higher.

Comment about Propositions

The conditions of Propositions 3 - 7 are restrictive. They let us compare the games in which only one parameter differs, yet the parameters of the game $\Gamma$ are likely endogenous. In reality, these parameters may change simultaneously. For example, historically, technology advancement (an increase in $\mu$) has been accompanied by the advancement of the contractual mechanism (an increase in $\beta$ and $\gamma$); similarly, historically, player outside options were hardly constant: they also depended on technology and legal conditions. These empirical regularities clearly violate the condition of Propositions 3 - 7 that all other parameters are fixed.

5. Discussion

Technology and contractual institutions are hardly independent. The factors contributing to pressures on contractual mechanism in present-day global economy include incompatibilities of contract law between the countries and deficiencies of international law and its enforcement (reviewed in Staiger (1995)), and difficulties of contract enforcement in the countries with poor legal systems, to where production was relocated due to the increase in foreign direct investment (reviewed in La Porta et. al. (1999), see also Carpio et. al. (2001)).

To sum up, firstly, internationalization of production makes it more costly to prove a breach of contract and receive a compensation once it is proven. This inference is just a restatement of the fact that legal systems of advanced economies are more mature than the international legal system, which cross-country contractual incompatibilities are exacerbated by weak international enforcement mechanisms. Perhaps, these developments result in downward pressure on $\beta$ and $\gamma$, and, accordingly, translate into worsening of investments incentives (Proposition 3). In this case, the current economic slowdown may be rooted in contractual system weakening.
Secondly, technological changes have markedly altered information processing, and have increased CEOs’ informational advantage over investors. Simultaneously, globalization of production and advancement of financial system provide the CEOs with new means to utilize their informational advantage. The overall effect of these changes is increased disparity between $\beta$ and $\gamma$ due to a decrease in $\beta$, not accompanied by a matching decrease in $\gamma$. We show that with costly contracts, the hold-up problem is less acute when players reneging costs are similar (Proposition 3 and 4).

We investigate how technological and contractual parameters affect ex ante ownership contract, incentives to invest, and ex post incentives to renege the ex ante contract. Currently observed increase of player reneging (corporate fraud and accounting violations), can be attributed to several economic parameters. We show that the increased frequency and scope of corporate crime can be driven by the following factors: advancement of production technology (an increase in $\mu$); decrease of investor outside option (a decrease in investment return ($\xi$)) and increase of CEO outside option (an increase in $\omega$); and effects of technological changes on contractual mechanism (decrease in $\beta$ and $\gamma$, and increase in their disparity), see Propositions 5, 6 – 7, and 3 – 4, respectively.

Making specific conclusions about the underlying changes of parameters that are causing an increase of CEO reneging requires further theoretical modeling and data analysis. This paper does not address the specifics of parameter changes, but only lists the possibilities consistent with the pattern of increased CEO reneging. Our results affirm the importance of well-functioning contractual institutions for investment efficiency in current economic environment, and call for attention to the issue of ownership endogeneity in the analysis of corporate financial and production decisions.

**Concluding Remark**

The data decisively shows that in countries with weak contact enforcement institutions, investment is suboptimal, see La Porta et. al. (1999), (2000) reviews. This suboptimality reflects current production technology, with its dependence on contractual institutions. We suggest that recent managerial misconduct reflects managerial ex post activities to attain more favorable surplus sharing, as a consequence of technology change of the 1990s.
References


Appendix

Proof of Theorem 1. To simplify, we say that a function is defined on a closed interval, when the function is actually well defined only on the respective open one. At the boundary points the left or the right limit of the function is considered.

We provide ‘unnecessary’ complete proof of Theorem 1. This simplifies presenting the proof of Theorem 2 and eases the comparison of equilibria in the games $\Gamma$ and $\tilde{\Gamma}$.

Lemma 1. Consider the following system of equations for $t \in [0, \tilde{t}]$:

$$t \Phi'(q) - \omega = 0, \quad q = (q_1, q_2)$$

$$q_1 = q_2 \geq 0,$$  \hspace{1cm} (4)

and the following system of equations for $t \in [\tilde{t}, 1]$:

$$t \Phi'(q) - \omega \geq 0, \quad q = (q_1, q_2)$$

$$q_1 \geq q_2 \geq 0,$$ \hspace{1cm} (7)

Then, there exists a unique solution $\hat{q}(t) = (\hat{q}(t), \hat{q}(t))$ for any $t \in [0, \tilde{t}]$, of the system (4) – (6), and a unique solution $\hat{q}(t) = (\hat{q}(t), \hat{q}(t))$ of the system (7) – (9) for any $t \in [\tilde{t}, 1]$. The function $\hat{q}$ is continuous and twice continuously differentiable for any $t \neq \tilde{t}$, where

$$\tilde{t} = \frac{\omega}{\omega + \xi}, \quad \text{and} \quad \Phi'(\hat{q}(\tilde{t})) = \omega + \xi, \hspace{1cm} (10)$$

and $\hat{q}(t)$ is a solution of the following equation:

$$\Phi'(\hat{q}(t)) = \begin{cases} \frac{\omega}{t} : \forall t \in [0, \tilde{t}] \\ \frac{\xi}{(1-t)} : \forall t \in [\tilde{t}, 1] \end{cases}. \hspace{1cm} (11)$$

Proof of Lemma 1: The derivation is straightforward, also see Varian (2002). □

Step 2. Let $\tilde{\Gamma}(t)$, with $i = 1, 2$, or $p$, denote a subgame of the game $\tilde{\Gamma}$ which starts with a fixed $t \in [0, 1]$. There exists an equilibrium of the game $\tilde{\Gamma}(t)$. The equilibrium is unique and player investments are $\hat{q}(t) = (\hat{q}(t), \hat{q}(t))$, where $\hat{q}(t)$ is a solution of the system of equations (4) – (6).
Proof of Step 2: Let \( \tilde{q}^i(t) = (\tilde{q}^i_1(t), \tilde{q}^i_2(t)) \) denote equilibrium investment in the game \( \hat{\Gamma}^i(t) \). Since it is suboptimal for either player to invest more than the other player invests, in any equilibrium \( \tilde{q}^i_1(t) = \tilde{q}^i_2(t) \), and equation (6) holds in any equilibrium. From player optimization and Pareto optimality considerations, equations (4) and (5) or (7) and (8) hold in equilibrium as well. From Lemma 1, the systems (4) – (6) and (7) – (9) always have a unique solution. Thus, \( \tilde{q}^i(t) = \hat{q}(t) \) and Step 2 is proven. □

Step 3: There exists an equilibrium of the game \( \hat{\Gamma}^p \). It is unique, and in equilibrium: \( (\hat{\chi}, \hat{t}^p) \), where \( \hat{t}^p = \check{t} \).

Proof of Step 3: From Steps 1 and 2, social planner objective in the game \( \hat{\Gamma}^p \) can be written as:
\[
T(t) = \max_{t \in [0,1]} [\Phi(\hat{q}(t)) - (\omega + \xi)\hat{q}(t)].
\]
Since \( T(0) = T(1) = 0 \), in any equilibrium \( t \in (0,1) \), because \( T(t) > 0 \) for any \( t \in (0,1) \). Social planner optimization gives:
\[
\hat{A}(t) \frac{d\hat{q}(t)}{dt} = 0, \quad \text{where} \quad \hat{A}(t) = [\Phi'(\hat{q}(t)) - (\omega + \xi)].
\]
From differentiation of equation (11) with respect to \( t \), and any \( t \neq \check{t} \)
\[
\frac{d\hat{q}(t)}{dt} = \begin{cases} 
-\frac{\xi}{\Phi''(\hat{q}(t))} = -\frac{|\Phi'(\hat{q}(t))|^2}{\xi\Phi''(\hat{q}(t))} > 0 : \forall t \in [0,\check{t}) \\
\frac{\xi}{(1-t)^2\Phi''(\hat{q}(t))} = \frac{|\Phi'(\hat{q}(t))|^2}{\xi\Phi''(\hat{q}(t))} < 0 : \forall t \in (\check{t},1). 
\end{cases}
\]
From (13), at any \( t \neq \check{t} \) we have \( \frac{d\hat{q}(t)}{dt} \neq 0 \). Thus, in any equilibrium of the game \( \hat{\Gamma}^p \), if \( t \neq \check{t} \) we have:
\[
\Phi'(\hat{q}(t)) - \omega + \xi = 0.
\]
But equation (14) does not hold for \( t \neq \check{t} \), see equation (10). Thus, the game \( \hat{\Gamma}^p \) has a unique equilibrium, \( \check{t}^p = \check{t} \), and Step 3 is proven. □

Step 4. There exist a unique equilibrium in each game \( \hat{\Gamma}^i \), with \( i = 1, 2 \), and:
\[
\check{t}^2 \leq \check{t}^p \leq \hat{t}^1 \quad \text{and} \quad \hat{q}^i = \hat{q}(\check{t}^p) \leq \hat{q}^p.
\]

Proof of Step 4. The proof is by contradiction. Let the outcome \( \check{o} \) with actions \((\check{t}, \check{q})\), where \( \check{t} < \check{t}^p \), be an equilibrium of the game \( \hat{\Gamma}^1 \). From Lemma 1, there exists an outcome \( \check{o} \), with actions \((\check{t}, \check{q})\), in which \( \check{q} = \check{q} \) and \( \check{t} > \check{t} \). Since the CEO’s payoff from outcome \( \check{o} \) is higher than from \( \check{o} \), the outcome \( \check{o} \) cannot be an equilibrium, and equation (15) is proven.
From Lemma 1 and equation (15), player objectives in the games \( \hat{\Gamma}_1 \) and \( \hat{\Gamma}_2 \) can be written as:

\[
\hat{\Gamma}_1: \quad \hat{V}(t) = \max_{t \in [\tilde{t}, 1]} \left[ t\Phi(\hat{q}(t)) - \omega \hat{q}(t) \right],
\]

\[
(16)
\]

\[
\hat{\Gamma}_2: \quad \hat{\Pi}(t) = \max_{t \in [0, \tilde{t}]} \left[ (1 - t)\Phi(\hat{q}(t)) - \xi \hat{q}(t) \right].
\]

(17)

Thus, in equilibria of the games \( \hat{\Gamma}_1 \) and \( \hat{\Gamma}_2 \) we have:

\[
\hat{\Gamma}_1: \quad \hat{V}'(t) = \frac{d}{dt} \hat{A}(t) + \Phi(\hat{q}(t)) = 0, \quad \text{where} \quad t \in [\tilde{t}, 1],
\]

\[
\hat{\Gamma}_2: \quad \hat{\Pi}'(t) = \frac{d}{dt} \hat{A}(t) - \Phi(\hat{q}(t)) = 0, \quad \text{where} \quad t \in [0, \tilde{t}],
\]

where \( \hat{A}(t) \) is given by equation (12). The second derivatives of equations (16) and (17) with respect to \( t \) are negative:

\[
\hat{\Gamma}_1: \quad \hat{V}''(t) = \frac{d^2}{dt^2} \hat{A}(t) + \Phi'(\hat{q}(t)) + \Phi''(\hat{q}(t)) \frac{d\hat{q}(t)}{dt} \frac{d\hat{q}(t)}{dt} < 0: \forall t \in (\tilde{t}, 1],
\]

\[
\hat{\Gamma}_2: \quad \hat{\Pi}''(t) = \frac{d^2}{dt^2} \hat{A}(t) - \Phi'(\hat{q}(t)) + \Phi''(\hat{q}(t)) \frac{d\hat{q}(t)}{dt} \frac{d\hat{q}(t)}{dt} < 0: \forall t \in [0, \tilde{t}],
\]

because twice differentiation of equation (11) with respect to \( t \) gives a negative \( \frac{d^2\hat{q}(t)}{dt^2} \) for any \( t \in [0, 1] \), if \( t \neq \tilde{t} \):

\[
\frac{d^2\hat{q}(t)}{dt^2} = \begin{cases} 
\frac{-d\hat{q}(t)}{dt} \frac{1}{2} \times 2 \left[ \Phi'(\hat{q}(t)) \right]^2 - \left[ \frac{\Phi'}{\Phi''} \right]^2 \Phi''' \frac{d\hat{q}(t)}{dt} & < 0: \forall t \in [0, \tilde{t}] \\
\frac{d\hat{q}(t)}{dt} \frac{1}{2} \times 2 \left[ \Phi'(\hat{q}(t)) \right]^2 - \left[ \frac{\Phi'}{\Phi''} \right]^2 \Phi''' \frac{d\hat{q}(t)}{dt} & < 0: \forall t \in (\tilde{t}, 1] 
\end{cases}
\]

Thus, each equation, (16) and (17), has a unique interior maximizer, from which the equilibrium of each game \( \hat{\Gamma}^i \) exists and is unique, and Step 4 and Theorem 1 are proven. \[ \square \]

5.0.1. Proof of Theorem 2. Step 1.

From the continuity and compactness of action spaces and quasi-convexity of player payoffs, there exists an equilibrium of the game \( \Gamma^i \) with \( i = 1, 2 \) or \( p \), see for example, Fudenberg and Tirole, (1991). Next, we derive an equilibrium and demonstrate its uniqueness.
Lemma 1. Consider the following system of equations

\[ [1 - x - (r - s)] \Phi'(q) - \xi = 0, \quad q = (q_1, q_2) \quad (18) \]
\[ [x + r - s)] \Phi'(q) - \omega \geq 0, \quad (19) \]
\[ q_1 = q_2 \geq 0, \quad (20) \]
\[ \Phi(q) - \beta B'(r) = 0, \quad (21) \]
\[ \Phi(q) - \gamma B'(s) = 0, \quad (22) \]

Then, there is no solution of the system of equations (18) – (22) for \( x \in [0, \tilde{x}) \), and there exists a unique solution \((q(x), s(x), r(x))\) of the system (18) – (22) for \( x \in [\tilde{x}, 1] \). This solution is continuous and twice continuously differentiable for \( x \in (\tilde{x}, 1] \), where \( \tilde{x} \) is:

\[ \tilde{x} = \frac{\omega}{\omega + \xi} - [\tilde{r} - \tilde{s}] \]

and \( \tilde{r} = r(\tilde{x}) \) and \( \tilde{s} = s(\tilde{x}) \) are solutions of:

\[ \Phi'(\tilde{q}^p) = \omega + \xi, \quad \text{and} \quad \Phi'(\tilde{q}^p) = \beta B'(\tilde{r}) \quad \text{and} \quad \Phi'(\tilde{q}^p) = \gamma B'(\tilde{s}), \]

which are unique from the properties of the functions \( \Phi \) and \( B \). [[If \( \tilde{x} \leq 0 \), there always exists a solution of the system of equations (18) – (22) for any \( x \in [0, 1] \), and \( q(0) \leq \tilde{q}^p ]

**Proof of Lemma 1:** Two cases are possible:

**Case I:**
\[ \tilde{x} > 0, \quad [\text{Case I}], \]
and **Case II:**
\[ \tilde{x} \leq 0, \quad [\text{Case II}], \]

To proof Lemma 1 for Case I, let

\[ t(x) = x + r(x) - s(x). \]

Then, the system of equations (18) – (20) coincides with the system (7) – (9). In Case I, there exists \( \tilde{x} > 0 \), such that \( t(\tilde{x}) = \tilde{t} \) and \( q(x) = \tilde{q}(t(x)) \) for any \( x \in [\tilde{x}, 1] \), and for any \( x \in [0, \tilde{x}) \), from equation (18) (and using equation (10)) we have

\[ \Phi'(q) < \omega + \xi, \]
and from equation (19):

\[ \Phi'(q) > \omega + \xi, \]
which is a contradiction, thus, no solution of the system of equations (18) – (22)
extists for \( x \in [0, \bar{x}) \).

Keep \( x \) and \( q = (q, q) \) fixed and differentiate equations (20) and (21) with respect
to \( r \) and \( s \) to show that these derivatives are negative:

\[
-\beta B''(r) < 0 \quad \text{and} \quad -\gamma B''(s) < 0.
\]

Thus, from the properties of \( \Phi \) and \( B \), there exist a unique solution of each equation
(20) and (21) for any fixed \( x \) and \( q = (q, q), q \in [0, \infty) \). Let 
\( r^q(x) \) and \( s^q(x) \) denote these solutions, respectively. Differentiating equations (20) and (21) with respect to \( q \), and keeping \( x \) fixed, gives us 
\[
\frac{dr^q(x)}{dq} \bigg|_{x=\text{const}} = \frac{\Phi'(q)}{\beta B''(r^q(x))} > 0, \quad \frac{ds^q(x)}{dq} \bigg|_{x=\text{const}} = \frac{\Phi'(q)}{\gamma B''(s^q(x))} > 0.
\]

From which for any fixed \( x \), the derivative of equation (18) with respect to \( q \) is
negative:

\[
(1 - x - r + s)\Phi''(q) - \left[ \frac{1}{\beta B''(r^q(x))} - \frac{1}{\gamma B''(s^q(x))} \right] \Phi'(q) < 0 : \forall x \in [\bar{x}, 1],
\]
due to the properties of the functions \( B \) and \( \Phi \).

Since we assume that investment in the project is positive for any \( t \in (0, 1) \), an expression

\[
\lim_{q \to 0} [1 - x - r + s] \Phi'(q) - \xi > 0
\]
is positive. Thus, a unique interior solution of equation (18) exists, which we denote
by \( q(x) \). From uniqueness and existence of \( r^q(x) \), \( s^q(x) \) and \( q(x) \), there exist a
unique \( r(x) = r^q(x) \), and a unique \( s(x) = s^q(x) \) and, thus, a unique solution
of the system of equations (18) – (22). This solution \((q(x), r(x), s(x))\) is continuous
and twice continuously differentiable from the properties of the underlying functions.

Since Case II follows from Case I straightforwardly, Lemma 1 is proven. \( \square \)

Step 2: Let the outcome \( o^* \) with actions \((x^*, q^*, s^*, r^*)\) and \( x^* \in [0, \bar{x}) \) be an
equilibrium of the game \( \Gamma(x^*) \) (the game \( \Gamma(x^*) \) is the subgame of the game \( \Gamma \)
that starts when the share \( x^* \) is chosen). Then, \( q^* < \tilde{q}^p \), and at \( x = x^* \) we have:

\[
\frac{dq}{dx} \bigg|_{x=x^*} = \frac{1}{\frac{\Phi''(q)}{\Phi'} - \frac{B'(r^*)}{B''(r^*)} - \frac{B'(s^*)}{B''(s^*)}}, \quad (23)
\]
where \( \Phi = \Phi(q^*), \Phi' = \Phi'(q^*), \Phi'' = \Phi''(q^*), \) and \( r^* \) and \( s^* \) are solutions of
\[
\Phi(q^*) = \beta B'(r) \quad \text{and} \quad \Phi(q^*) = \gamma B'(s).
\]

**Proof of Step 2:** Notice, that Step 2 is needed only for the proof only when Case I occurs.

Since the system of equations (18) – (22) has no solution for \( x \in [0, \hat{x}] \), in any equilibrium of the game \( \Gamma(x^*) \) with \( x^* \in [0, \hat{x}] \) we have:
\[
[x^* + r^* - s^*] \Phi'(q^*) - \omega = 0
\]
for efficiency. Also for efficiency, in equilibrium equations (20) – (22) hold, from which \( q^* < \hat{q} \) follows immediately. Differentiation of equations (24) and (25) provides equation (23).

Step 3. Let \( \Gamma_i(x) \), with \( i = 1, 2, \) or \( p \), denote the subgame of the game \( \Gamma_i \) which starts with a fixed \( x \in [\hat{x}, 1] \). Then, there exists an equilibrium of the game \( \Gamma_i(x) \). It is unique and player equilibrium actions are \( (q(x), s(x), r(x)) \), i.e., the solution of the system of equations (18) – (22).

**Proof of Step 3:** Analogous to Step 2 of Theorem 1.

Step 4. An equilibrium of the game \( \Gamma_p \) is unique, and in equilibrium, \( x^{ps} = \hat{x}, q^{ps}(\hat{x}) = \hat{q} \) and \( t^{ps} = t(\hat{x}) = \hat{t} \).

**Proof of Step 4:** Follows from above.

Step5. Let \( \Gamma_{x^h \in X} \) be the subgames which start with a fixed \( \text{ex ante} \) share \( x \), for which the cumulative equilibrium player surplus is the highest. Then, there could exist only two such subgames of the game \( \Gamma \): one with the CEO’s share belonging to \( [\hat{x}, 1] \), and another with his share lower than \( \hat{x} \). Player investments are equal in both these subgames.

**Proof of Step 5:** Let \( X \) denote a set of \( \text{ex ante} \) shares, for which player cumulative surplus in the equilibrium of the subgame of the game \( \Gamma \) that starts with \( x^h \in X \) reaches its highest level:
\[
S(a) = \max_x [\Phi(q) - (\xi + \omega)q - \beta_1 B(r) - \gamma B(s)].
\]

Let the outcome \( o^* \) with actions \( (x, q^*, s^*, r^*) \) denote an equilibrium of the game \( \Gamma_{x \in X} \). From Step 2 and differentiation of equation (26) at any \( x \in X \) we have:
\[
\left\{ \left[ 1 - \frac{B'(r^*) + B'(s^*)}{B''(r^*)} \right] \Phi'(q^*) - [\xi + \omega] \right\} \times \frac{dq}{dx} \bigg|_{x \in X} = 0 : \forall x \in X.
\]
From equation (24):
\[
\frac{dr}{dx}\bigg|_{x=x^*} = \frac{dr}{dq}\bigg|_{q=q^*} \times \frac{dq}{dx}\bigg|_{x=x^*} = \frac{\Phi'(q)}{\beta B''(r^q)} \frac{dq}{dx}\bigg|_{x=x^*},
\]
\[
\frac{ds}{dx}\bigg|_{x=x^*} = \frac{ds}{dq}\bigg|_{q=q^*} \times \frac{dq}{dx}\bigg|_{x=x^*} = \frac{\Phi'(q)}{\gamma B''(s^q)} \frac{dq}{dx}\bigg|_{x=x^*},
\]
and from equation (23) \(\frac{dq}{dx}\bigg|_{x} \neq 0\), for any \(x \neq \hat{x}\) we infer that:
\[
\left[1 - \frac{B'(r^s)}{B''(r^s)} + \frac{B'(s^*)}{B''(s^*)}\right] \Phi'(q^*) - [\xi + \omega] = 0.
\]  
(27)

From Step 2 and equation (27), the actions \((q^{h^s}, s^{h^s}, r^{h^s})\) are identical in all equilibria of \(\Gamma_{x^h \in \mathbb{X}}\).

From Lemma 1, there exists a unique \(x \in [\hat{x}, 1]\), such that equation (27) holds. Thus, there exists a unique subgame of the game \(\Gamma\) starting with ex ante CEO share belonging to \([\hat{x}, 1]\), in which total equilibrium surplus is the highest. Let \(x^{h^1} \in [\hat{x}, 1]\) denote such a share. Then, in any game \(\Gamma_{x^h \in \mathbb{X}}\) we have: \(q^{h^1} = q(x^{h^1}), s^{h^1} = s(x^{h^1}),\) and \(r^{h^1} = r(x^{h^1}).\) But there exists at most one \(x^{h^2} < \hat{x}\), which solves equation (25):
\[
\left[x + r^{h^s} - s^{h^s}\right] \Phi'(q^{h^s}) - \omega = 0.
\]
Thus, at most one equilibrium exists of the game \(\Gamma(x^{h^2})\) with \(x^{h^2} < \hat{x}.\) From Step 2 and equation (27), the actions \((q^{h^s}, s^{h^s}, r^{h^s})\) are identical in all equilibria of \(\Gamma_{x^h \in \mathbb{X}}\), we have: \(q^{h^s} = q(x^{h^2}), s^{h^s} = s(x^{h^2}),\) and \(r^{h^s} = r(x^{h^2}),\) and Step 5 is proven. \(\square\)

Step 6. Let \(x^{1*}\) and \(x^{2*}\) denote CEO ex ante shares in some equilibria of the games \(\Gamma^1\) and \(\Gamma^2\). Then:
\[
x^{2*} \leq \hat{x} \leq x^{1*}.
\]  
(28)

**Proof of Step 6:** Analogous to the proof of equation (15), Step 4 of Theorem 1.\(\square\)

Step 7. There exists a unique equilibrium in the game \(\Gamma^1.\)

**Proof of Step 7:** From Lemma 1 and equation (28), in any equilibrium of the game \(\Gamma^1\) we have \(x \in [\hat{x}, 1]\), and player objectives can be expressed as functions of \(x:\)
\[
\hat{V}(x) = V(x, q(x), r(x), s(x)) : \forall x \in [\hat{x}, 1],
\]
\[
\hat{\Pi}(x) = \Pi(x, q(x), r(x), s(x)) : \forall x \in [\hat{x}, 1].
\]
Then, player surplus expressed as a function of $x$ is:
\[
\hat{S}(x) = \hat{V}(x) + \hat{\Pi}(x).
\]

In any equilibrium of the game $\Gamma^1$:
\[
\hat{V}'(x) = 0.
\]

From Step 3, for any $x \in [\tilde{x}, 1]$ equilibrium profit $\hat{\Pi}(x)$ of the game $\Gamma^i(x)$ decreases with $x$:
\[
\hat{\Pi}'(x) < 0.
\]  
(29)

In the equilibrium of the game $\Gamma^i(x)$ with $x \in [\tilde{x}, x^{h_1*}]$, we have:
\[
\hat{S}'(x) = \hat{\Pi}'(x) + \hat{V}'(x) > 0 : x \in [\tilde{x}, x^{h_1*}],
\]

because
\[
\hat{S}'(x) = \left[ A(x) - \left[ \frac{B'(r(x))}{B''(r(x))} + \frac{B'(s(x))}{B''(s(x))} \right] \Phi'(q(x)) \right] \frac{dq(x)}{dx} = \left\{ \begin{array}{ll}
> 0 : x \in [\tilde{x}, x^{h_1*}] \\
< 0 : x \in [x^{h_1*}, 1] \end{array} \right.,
\]  
(30)

where
\[
A(x) = \Phi'(q(x)) - [\xi + \omega].
\]

Thus, from equations (29) and (30):
\[
\hat{V}'(x) > 0 \text{ for any } x \in [\tilde{x}, x^{h_1*}],
\]
and $x \in [\tilde{x}, x^{h_1*}]$ cannot be an equilibrium of the game $\Gamma^1$. From which:
\[
q^{1*} < q^{h*} < q^{p*},
\]
because from equations (18), (20) and (21), we have $\frac{dq(x)}{dx} < 0$ for $x \in (\tilde{x}, 1]$:
\[
\frac{dq(x)}{dx} = \left\{ \frac{\Phi'(q(x))}{\Phi'(q(x))} \frac{1}{\Phi'(q(x))} - \Phi'(q(x)) \left[ \frac{B'(r(x))}{B''(r(x))} - \frac{B'(s(x))}{B''(s(x))} \right] \right\} < 0 : \forall x \in (\tilde{x}, 1].
\]  
(31)

Let there exist two equilibria of the game $\Gamma^1$, with actions $(\hat{x}, \hat{q}, \hat{r}, \hat{s})$ and $(\check{x}, \check{q}, \check{r}, \check{s})$. From Step 3, an equilibrium originating at any $x$ is unique, so $\hat{x} \neq \check{x}$. For efficiency, the surplus in all equilibria of the game $\Gamma^1$ is equal:
\[
\hat{S}(\hat{x}) = \hat{S}(\check{x}),
\]
which cannot hold because from equation (30)

$$\tilde{S}'(x) < 0 : \forall x \in [x^{h_1*}, 1].$$

Thus, in any equilibrium, CEO ex ante shares, $\tilde{x}$ and $\tilde{x}$, belong to $[x^{h_1*}, 1]$, but equation (30) only one of these shares could be an equilibrium. Thus, equilibrium of the game $\Gamma^1$ is unique, and Step 7 is proven. □

Step 8. There exists a unique equilibrium of the game $\Gamma^2$.

**Proof of Step 8:** Analogous to Step 7, and Theorem 2 is proven. □

**Summary of equilibrium properties [Theorem 2]**

$$\tilde{x}^{2*} < x^{h_2*} < \tilde{x} < x^{h_1*} < x^{1*},$$

$$q_i^{i=1,2*} < \tilde{q}_i^{i=1,2*} \leq q_i^{h*} < \tilde{q}_i^p = q_i^{p*},$$

$$t^{2*} < t^{h_2*} < t^{2*} < t^{p*} < t^{h_1*} < t^{1*} < t^{h_2*},$$

$$t^{2*} < t^2 < t^{p*} = \tilde{t}^p < \tilde{t}^1 < t^{1*},$$

$$S^{1*} < S^{2*} < S^{p*} < S^{h*}.$$

**Proof of Proposition 1.** From equations (11), (16) and (17):

$$\hat{\Gamma}^1: \hat{V}'(t) = \left[\Phi'(\hat{q}(t))\right]^2 \hat{A}(t) + \Phi = \begin{cases} 0 : \forall t \in \left[\tilde{t}, \tilde{t}^1\right) \\ > 0 : \forall t \in (\tilde{t}^1, 1] \end{cases},$$

$$\hat{\Gamma}^2: \hat{\Pi}'(t) = -\frac{\left[\Phi'(\hat{q}(t))\right]^2}{\omega\Phi''(\hat{q}(t))} \hat{A}(t) - \Phi = \begin{cases} > 0 : \forall t \in [0, \tilde{t}^2) \\ < 0 : \forall t \in (\tilde{t}^2, \tilde{t}] \end{cases},$$

where $\hat{A}(t)$ is given by equation (12). Consider $\tilde{t} > \tilde{t}$ such that $\hat{q}(\tilde{t}) = \hat{q}^2$. Then

$$\hat{V}'(\tilde{t}) - \hat{\Pi}'(\tilde{t}^2) = \hat{V}'(\tilde{t}) = \hat{A}(t) \frac{\left[\Phi'(-\hat{q}(t))\right]^2}{\frac{1}{\xi} - \frac{1}{\omega}} \left[\frac{1}{\xi} - \frac{1}{\omega}\right] \geq 0 \text{ if } \omega \leq \xi.$$

Since the function $\hat{V}'$ decreases with $t$, we have $\tilde{t}^1 \geq \tilde{t}$, and $\hat{q}^{i=1} = \hat{q}(\tilde{t}^1) \leq \hat{q}^2$ follows from equation (13). Since for any $q < q^{h*}$ equilibrium surplus increases with $q$, the surplus is higher in the game with a higher equilibrium investment, that is when the contract is chosen by a player with a higher outside option, and Proposition 1 is proven. □

**Proof of Proposition 2.** From equations (14) and (27):

$$q^{p*} \leq \hat{q}^p.$$
and from the proof of Theorem 2:

\[ q^2 < q^{h2*} \quad \text{and} \quad q^1 < q^{h1*} \]

and

\[ x^{2*} \leq \tilde{x} < x^{h1*} < x^{1*} \quad \text{and} \quad t^{2*} \leq \tilde{t} < t^{h1*} < t^{1*}, \]

where \( t^{i*} = x^{i*} + r^{i*} - s^{i*} \).

The proof that \( q^1 < q^2 \) (when \( \omega \leq \xi \)) is analogous to the proof of Proposition 1. From Theorem 2, in the game \( \Gamma^1 \) we have \( x^{1*} \in [x^{h1*}, 1] \). Consider the game \( \Gamma_i(\tilde{x}) \), where \( \tilde{x} \in [\tilde{x}, 1] \) and \( q(\tilde{x}) = q^{2*} \). Then, from the proof of Theorem 2:

\[ \tilde{x} \in [x^p*, 1], \]

because for \( x \in [\tilde{x}, 1] \) we have \( dq(x) \frac{dx}{dx} < 0 \) and \( q^{2*} < q^p* \). From Step 2 of Theorem 2, in the equilibrium of the game \( \Gamma_i(\tilde{x}) \) we have \((\tilde{x}, q(\tilde{x}), s(\tilde{x}), r(\tilde{x}))\), where \( q(\tilde{x}) = q^{2*} \), \( r(\tilde{x}) = r^{2*} \) and \( s(\tilde{x}) = s^{2*} \). For any \( x \in [\tilde{x}, 1] \), the function \( \tilde{V}' \) can be written as:

\[
\tilde{V}'(x) = \frac{dq(x)}{dx} V1(x) < 0, \tag{32}
\]

where \( \frac{dq(x)}{dx} \) is given by equation (30), and thus, \( V1(x) \) is:

\[
V1(x) = \left\{ \left[ 1 - \frac{B'(r(x))}{B''(r(x))} \right] \Phi'(q(x)) - [\omega + \xi] + \frac{\Phi''(\xi)}{[\Phi']^2} \right\}
\]

or as:

\[
\tilde{V}'(x) = \frac{dq(x)}{dx} V2(x) + \Phi(q(x)), \tag{33}
\]

where \( V2(x) \) is:

\[
V2(x) = \left\{ \left[ 1 - \frac{B'(s(x))}{B''(s(x))} \right] \Phi'(q(x)) - [\omega + \xi] \right\},
\]

In the game \( \Gamma^2 \) we have \( x^{2*} \in [0, \tilde{x}] \), and the following equation holds in equilibrium:

\[
\left. \frac{d\Pi}{dx} \right|_{x=x^{2*}} = \left\{ \Phi' - [\omega + \xi] - \frac{B'(r)}{B''(r)} \Phi' \right\} \frac{dq}{dx} \bigg|_{x=x^{2*}} - \Phi = 0,
\]

or

\[
\left. \frac{d\Pi}{dx} \right|_{x=x^{2*}} = \frac{dq}{dx} \bigg|_{x=x^{2*}} \left\{ \left[ 1 - \frac{B'(s)}{B''(s)} \right] \Phi' - \frac{\Phi''(\omega)}{[\Phi']^2} - [\omega + \xi] \right\} = 0,
\]
where \( \frac{dq}{dx} \bigg|_{x=x^2} \) is given by equation (23), and for brevity \( \Phi = \Phi(q^2) \), \( B(r) = B(r^2) \), \( B(s) = B(s^2) \), etc. Next, we calculate:

\[
\dot{V}'(x) = \frac{d}{dx} \left[ \frac{B'(r)}{B''(r)} - \frac{B'(s)}{B''(s)} \right] \Phi' + \left[ \frac{1}{\frac{dq}{dx} \bigg|_{x=x^2}} + \frac{1}{\frac{dq}{dx} \bigg|_{x=x^2}} \right] \Phi,
\]

\[
\frac{1}{\frac{dq}{dx} \bigg|_{x=x^2}} + \frac{1}{\frac{dq}{dx} \bigg|_{x=x^2}} = \frac{\Phi''}{\Phi'} - \frac{\Phi'}{\Phi} \left[ \frac{B'(r)}{B''(r)} - \frac{B'(s)}{B''(s)} \right] - \frac{\Phi''}{\Phi'} - \Phi' \left[ \frac{B'(r)}{B''(r)} - \frac{B'(s)}{B''(s)} \right] < 0
\]

\[
\dot{V}'(x) = \frac{d}{dx} \left[ \frac{B'(s)}{B''(s)} - \frac{B'(r)}{B''(r)} \right] \Phi' + \frac{\Phi''}{\Phi'} \left[ \xi - \omega \right] < 0 \text{ if } \omega \leq \xi.
\]

From our calculation:

\[
\dot{V}'(x) > 0 \text{ if } \omega \leq \xi,
\]

which gives \( \tilde{x} < x^1 \), and thus:

\[
q^{1s} \leq q^{2s} \text{ if } \omega \leq \xi,
\]

and

\[
q^{1s} < q^{2s} < q^{h} < q^p \text{ if } \xi \leq \omega \text{ and } \beta < \gamma.
\]

Since for any \( q < q^h \) equilibrium surplus increases with \( q \), equilibrium surplus is higher in the game, where ex ante contract is chosen by a more committed player (investor), and Proposition 2 is proven. \( \Box \)

**Proof of Proposition 3.** Notation and Preliminaries for the Proofs of Propositions 3 – 4: Let \( (x^s, q^s, r^s, s^s) \) and \( (x^{II}, q^{II}, r^{II}, s^{II}) \) denote player actions in the equilibria of \( \Gamma = \Gamma(o^I) \) and \( \Gamma^{II} = \Gamma(o^{II}) \), such that The superscripts “I” and “II” designate the respective games, and to ease notation, we drop the superscripts when possible. Let \( t(x) \) denote:

\[
t(x) = x + r(x) - s(x)
\]
Let $\tilde{x}$ denote such $x$ that $q^I(\tilde{x}) = q^{II}(x^{II^*}) = q^{II^*}$, then:

$$\Phi(\tilde{x}) = \Phi^{II^*} = \beta^I B'(r^I(\tilde{x})) = \beta^{II} B'(r^{II^*})$$

$$\frac{\xi}{\Phi'(q^{II^*})} = \left[ 1 - t^I(\tilde{x}) \right] = \left[ 1 - t^{II^*} \right] = \frac{\xi}{\Phi^{II^*}}$$

$$t^I(\tilde{x}) = t^{II^*}, \quad r^I(\tilde{x}) > r^{II^*}, \quad s^I(\tilde{x}) = s^{II^*}, \quad \tilde{x} < x^{II^*},$$

From equation (33) we have:

$$\dot{V}^{II}(\tilde{x}) - \dot{V}^{II^*}(x^{II^*}) = V^2(x^{II^*}) \left\{ \frac{dq(x)}{dx} \bigg|_{x=\tilde{x}} - \frac{dq^{II^*}(x)}{dx} \bigg|_{x=x^{II^*}} \right\} > 0,$$

because

$$\frac{dq(x)}{dx} \bigg|_{x=\tilde{x}} > \frac{dq(x)}{dx} \bigg|_{x=x^{II^*}}.$$  

thus, $\dot{V}(\tilde{x}) > 0$, from which $\tilde{x} < x^{I^*}$ and $t^{II^*} = t^{II}(\tilde{x}) < t^I(x^{I^*}) = t^I$. Thus:

$$t^{II^*} < t^I,$$

and, due to equation (31):

$$q^{I^*} < q^{II^*}.$$  

Let $\bar{x}$ such that $q^{II}(\bar{x}) = q^{I^*}$. Then, the CEO’s payoff is higher in the game in $\Gamma^{II}(\bar{x})$ than in $\Gamma^I(x^{I^*})$:

$$V^{I^*} = \dot{V}(x^{I^*}) < \dot{V}^{II}(\bar{x}),$$

because from the properties of the function $B$:

$$\beta^I B(x^{I^*}) > \beta^{II} B(\bar{x}),$$

and since $x$ is chosen by the CEO, we have:

$$V^{I^*} < \dot{V}(\bar{x}) \leq V^{II^*}.$$  

From $q^{I^*} < q^{II^*}$ we have:

$$\Pi^{I^*} < \Pi^{II^*},$$

because $t^{I^*} > t^{II^*}$, and investor profit from deviation to $q^{I^*}$ in the game $\Gamma^{II}$ provides him with a higher than $\Pi^{I^*}$ profit. Thus, both players benefit from an increase in $\beta$, and Proposition 3 is proven.  

**Proof of Proposition 4.** Let $\beta^I + \gamma^I = \beta^{II} + \gamma^{II}$ and assume $\beta^I < \beta^{II}$. From the proof of Proposition 3 (or from equation (32)), in the equilibrium of the game $\Gamma^1$,
the asset value does not depend on $\gamma$.

$$V_1(x) < 0 \text{ if } x \in (x^{h*}, x^{l*}) \text{ and } V_1(x) > 0 \text{ if } x \in (x^{l*}, 1),$$

and in equilibrium $V_1(x^*) = 0$.

Let $\tilde{x}$ such that $q_I'(\tilde{x}) = q^{II}(x^{II^*}) = q^{II*}$, then:

$$V_1'(\tilde{x}) < V_1^{II}(x^{II^*}) = 0,$$

because $r^I(\tilde{x}) > r^{II^*}$. Thus,

$$\tilde{x} < x^{l*},$$

and

$$q^{I*} < q^{II*},$$

because from equation (32) we have:

$$\dot{V}^{II}(\tilde{x}) - \dot{V}^{II}(x^{II^*}) < \left\{ \frac{dq^I(x)}{dx} \bigg|_{x=\tilde{x}} - \frac{dq^{II}(x)}{dx} \bigg|_{x=x^{II^*}} \right\} \times V_1(x^{II^*}) < 0,$$

because

$$\frac{dq^I(x)}{dx} \bigg|_{x=\tilde{x}} > \frac{dq^{II}(x)}{dx} \bigg|_{x=x^{II^*}},$$

thus, $x^{II^*} < \tilde{x}$ and $t^{II^*} = t^I(x^{II^*}) < t^I(\tilde{x})$

$$x^{I*} < \tilde{x} < x^{II^*}, \quad t^{I*} < t^{II^*} \quad \text{and} \quad q^{II^*} < q^{I*},$$

from which

$$\dot{V}^* = \dot{V}(\tilde{x}) \leq \dot{V}^*,$$

and CEO equilibrium payoff is lower in the game $\Gamma^{II}$ than in $\Gamma^I$.

Consider investor deviation to $q^{II^*}$ in the game $\Gamma^I(x^{I*})$. Then,

$$\Pi^{II^*} = \Pi(x^{II^*}, q^{II^*}, s^{II^*}, r^{II^*}) < \Pi(x^{I*}, (q^{I*}, q^{II^*}), s^{II^*}, r^{II^*}) < \Pi^{I^*},$$

because $x^{I*} < x^{II^*}$. Thus, investor equilibrium profit is lower in the game $\Gamma^{II}$ than in $\Gamma^I$, and Proposition 4 is proven. \qed
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Table I presents the number of articles in the listed publications, with the search words in the title or abstract during the listed periods.\(^\text{11}\)

Data was generated via ProQuest database

Media Identifiers (PMID): WSJ, NYT, FT: 7510, 7818, 32326
Search Example:
“Corporate AND Fraud AND PMID(7510) AND PDN(> 01/01/2002) AND PDN(< 05/31/2002)”

The terms “corporate, executive, business leaders, business ethics, management, investor trust” combined with “accountability, responsibility, investigations, subpoenas, arrests, scrutiny, allegations, criminal charges, oversight” exhibit similar frequencies in business news.

\(^\text{11}\)WSJ, NYT and FT stand for Wall Street Journal, New York Times (NYT) and Financial Times (London). Each column (III, IV, V) covers five months, with dates listed in the top raw.
Table 2

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Table II presents the number of articles in the listed publications, with the search words in the title or abstract during the listed (more current) periods.

Data was generated via ProQuest database

Media Identifiers (PMID): WSJ, NYT, FT: 7510, 7818, 32326
Search Example:
“Corporate AND Fraud AND PMID(7510) AND PDN(> 01/01/2002) AND PDN(< 05/31/2002)”
Figure 1

Equilibria of the Games $\hat{\Gamma}^i$

From Theorem 1 and Proposition 1: $\hat{t}^p \equiv \check{t}^p = \check{t}$, and

$\check{t}^2 < \check{t}^p < \check{t}^1$ and $\check{q}^1 < \check{q}^2$ if $\omega < \xi$.

From the proof of Theorem 1 (Lemma 1) we have:

$\check{q}(t) = (\min(q_1(t), q_2(t)), \min(q_1(t), q_2(t)))$,

where $q_1(t)$ and $q_2(t)$ are the respective solutions of equations (4) and (8):

$t\Phi'(q) - \omega = 0, \quad q = (q_1, q_1)$ (4)

$(1 - t)\Phi'(q) - \xi = 0, \quad q = (q_2, q_2)$ (8)
Figure 2

Equilibria of the Games $\hat{\Gamma}_p$ and $\Gamma_p$

From Theorems 1 and 2:

$q(x) = \hat{q}(t(x))$.

From Remark 1:

$q^{h_1*} = q^{h_2*} = q^{hs} < q^{ps} = \hat{q}^p$ and $t^{h_2*} < \hat{t}^p = t^{ps} < t^{h_1*}$. 
Figure 3

Equilibria of the Games $\Gamma^1$ and $\Gamma^2$

We have $x^{2*} < x^{1*}$ and $q^{1*} < q^{2*}$ if $\omega < \xi$ (Proposition 2)
Figure 4

Equilibria of the Games $\Gamma^1$, $\Gamma^2$ and $\Gamma^p$

We have $q^{1,2*} < q^{h*} < q^{p*} = \hat{q}^p$ and

$t^{2*} < t^{h2*} < t^{p*} < t^{h1*} < t^{1*}$ (Theorem 2)
University of California, Berkeley