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, the 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 recently noticeably increased, see Table I, 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

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[1]From Review & Outlook (Editorial), "CEOs in Handcuffs," Wall Street Journal; New York, N.Y.; Jul 26, 2002.

improve accounting and disclosure rules, oversight structure, etc. Related questions have been raised in Congress repeatedly, resulting in the Sarbanes-Oxley Act of 2002. 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 by Greenspan of his concern with the principal-agent problem. Our model permits to name "the avenues" (parameters) which create managerial incentives to engage in legal and accounting violations. We model manager-investor interactions as the principal-agent problem, in which players can engage in costly *ex post* reneging of their *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. We interpret anecdotic evidence of increased scope of managerial misconduct as support to our inferences.

We model manager-investor interactions as a game between parties, which make specific irreversible investments into a project (firm), and thereafter (*ex post*) divide the profit of the joint project according to an endogenously determined ownership allocation (surplus sharing). In such environments, the players have *ex post* incentives of reneging *ex ante* ownership allocation. In our model, *ex post,* players can unilaterally renege on *ex ante* contact at a cost. Player reneging costs are exogenous, increasing and concave in the magnitude of the requested adjustment of the *ex ante* contract: the higher this magnitude, the higher reneging expenses. We view reneging costs as characteristics of contractual institutions, with more advanced institutions characterized by higher costs. Ceteris paribus, higher costs create disincentives

for player reneging by lowering their expected reneging gains, hence, making their expected gains lower. With higher reneging costs, player *ex ante* property rights are more secure, and investment incentives – less distorted. We show that higher reneging costs lead to lower equilibrium expenses on *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).[2] For a contract theory perspective on the issues of corporate governance, see Tirole (2001).[3]

The corporate governance literature catering 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 see as reflecting more advanced contractual institutions.

Only a fraction of agency literature takes Demsetz' (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

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[2]Tirole (1999) review provides more technically demanding and open-ended perspective with suggestive directions for future research.

[3]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.[4] 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, because our game yields endogenous surplus division between management and investors. Agency models usually assume that surplus is evenly divided between the players (Nash bargaining), thus, ignoring the empirical data, which confirms ownership endogeneity.[5]

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 search for the hole, and fix 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,

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[4]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.
[5]See Anderlini and Felli (1997) for a setup with explicitly endogenous ownership.

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 parties costs of *ex post* reneging advantageously for management.

We identify five factors contributing to an increase of managerial reneging: advancement of production technology, decrease of player outside options (investment returns and executive compensation), 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. These factors weaken the contractual system, and affect both parties, CEO and investor, albeit differently. The resulting effect is an increase in managerial informational advantage over investors.

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. In Section 5, modified games are introduced and analyzed. The discussion and the concluding remark are presented in Section 6. 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 Γ. The game Γ is the 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 the games with x chosen by either player, and let Γ^1 denote the game in which the CEO chooses x, and Γ^2 – the game in which the investor chooses x. In addition, we consider a benchmark – the game Γ^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 ω to his effort, and the investor – an alternative project with a fixed investment return ξ. We let the joint CEO-investor project's net value be equal to

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

where a constant $\mu > 0$ characterizes technology, and $\mu P(F(\mathbf{q}))$ is the probability of successful operation of the project (for example, reliable operation of the project's product), when player actions are $\mathbf{q}$. 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 (aka Leontieff production function).[6] One also may interpret the values of ω and ξ as reflective of the degree of market competition for the CEOs and investors, with lower ω and ξ corresponding to higher competition in the respective market.

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 $(1-t)$ 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 *ex post* contractual expenses (i.e. transaction costs) are the synonyms. Consider CEO interactions with the Board of Directors. Then, the constants β and γ proxy player costs of *ex post* contractual adjustment. The data provides that CEO reneging costs decrease with (i.e., β decreases) with the length of CEO tenure, and increase with the number of board members and frequency of board meetings, see Hermalin and Weisbach (1988), (1991).

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

$$W(\mathbf{a}) = t\Phi(\mathbf{q}) - \beta B(r) - \omega q_1, \quad \mathbf{a} = (x, r, s, \mathbf{q}), \quad \beta \geq 0, \quad \omega \geq 0, \qquad (2)$$

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

where $\max(\beta, \gamma) > 0$ and $\max(\omega, \xi) > 0$. The vector $\mathbf{a} \in \mathbf{A}$, where $\mathbf{A}$ is the set of action profiles of the game Γ. The constants β and γ reflect that player reneging costs; and $\beta \neq \gamma$ indicates that their costs differ. In our game, *ex post* reneging is a

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[6]See Kremer (1993) for demonstration of wide applicability of this production function.

mechanism with which the players change their *ex ante* contract, and we interpret their reneging costs $\beta B(r)$ and $\gamma B(s)$ as their *ex post* transaction costs.

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] The 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 $v < 0$:

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

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

The condition $B(v) \equiv 0$ for $v < 0$ means that each player can reduce his ownership share at no cost. To ease presenting the proofs, we impose $P''' \leq 0$ and $B''' \leq 0$, and

$$\lim_{v \to 0} B(v) = 0 \quad \text{and} \quad \lim_{v \to 0} B'(v) = 0,$$

which entails zero fixed cost of reneging. We will allow nonzero fixed-cost of reneging in Section 5. For the given functions P and B, the game Γ^i has 5 parameters: μ, β, γ and ξ, ω:

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

and $i = 1$, 2 or p correspond to the CEO's, the investor's or the social planner choice of an *ex ante* contract (i.e., x). To sum up, the game Γ^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 $(1 - t)$.

In our model the CEO and the investor differ only by parameter values. Both players make irreversible investments into the project, and share its surplus *ex post*. Our specification is similar to a standard principal-agent problem, but we emphasize player similarity, which constitutes a departure from the standard perspective.

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[7]Absent reneging, the project would be implemented if property allocation gives each player a positive ownership share, i.e., for any $t \in (0, 1)$ investments are positive.

In our model, CEO-investor relationship is analogous to a relationship of two monopolists, each of whom maximizes his share of profit from relationship-specific investment in a jointly manufactured product.

We assume players to 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 Γ^i, in which ex ante and ex post contracts are restricted to be identical: $x \equiv t$.*[8]

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 Γ^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.   □

Let '^' 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 $\mathbf{q}^I < \mathbf{q}^{II}$ component-wise.

For the intuition behind the proof of Theorem 1, notice that in the subgame $\hat{\Gamma}^i(x)$, which starts after any x, best responses q_1 and q_2 are unique. We show that for each i, ownership assignment $\hat{t}^i$, at which player i payoff is the highest exists and 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 $\hat{\Gamma}^i$ investment distortion is smaller when ownership contract is proposed by the player with a higher outside option:*

$$\hat{\mathbf{q}}^1 \leq \hat{\mathbf{q}}^2 \quad if \quad \omega \leq \xi.$$

Proof. See Appendix.   □

Proposition 1 relates the size of investment distortion with player outside options, see Figure 1, p. 36. Proposition 1 and Theorem 1, in the game $\hat{\Gamma}^i$ with ($i = 1$ or 2), efficiency is achievable in the equilibrium, only when the outside option of the player who does not choose the ownership allocation is zero.

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[8]For example, non-reneging is optimal, when sunk cost of reneging is equal to (or exceeds) the project value in the game Γ^p with ω and ξ approaching zero.

Next, we study the game Γ. 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 Γ.

Theorem 2. *An equilibrium of the game Γ^i exists. Each player investment and surplus are bounded from above by his equilibrium surplus in $\hat{\Gamma}^i$. Equilibria of the games Γ^i with $i = 1, 2$ are unique.*

Proof. See Appendix. $\square$

To improve investment efficiency, two issues should be addressed, which can be called *ex ante* efficiency and *ex post* efficiency. The latter issue concerns with how to induce *ex ante* ownership allocation optimally, and, the former – player adherence to the *ex ante* contract. *Ex post* reneging makes player commitment to the *ex ante* contract incomplete, and causes underinvestment due to the divergence of *ex ante* and *ex post* incentives. Our main interest is *ex post* contractual efficiency. We focus on investment suboptimality driven by *ex post* reneging.

Our treatment of *ex ante* efficiency is primitive: clearly, the games Γ^i with $i = 1, 2$ are extremes, each game gives full advantage to the player who proposes an *ex ante* contract. We admit that "take it or leave it" offer about surplus sharing (which is exactly how *ex ante* ownership is allocated in our game) is unrealistic. It is more appropriate to model *ex ante* ownership allocation as a bargaining game between the players (similar to Rubinstein (1982) bargaining model). One would expect bargaining mechanism to reduce investment suboptimality.

Remark 1. *The game Γ^p has two equilibria, which differ by CEO shares only:*

$$\mathbf{q}^{p*} \leq \hat{\mathbf{q}}^p, \quad and \quad t^{p*2} \leq \hat{t}^p \leq t^{p*1},$$

and inequalities are strict if $\beta \neq \gamma$.

Proof. Follows from the proofs of Theorems 1 and 2. $\square$

Remark 1 establishes that in the equilibrium of the game Γ^p, the CEO's *ex post* ownership share is higher than his *ex ante* share. This occurs because reneging is cheaper for the CEO, and his optimal share adjustment is higher than for the

investor. From Remark 1, the firm value peaks at CEO equilibrium share of the game Γ^p, see Figure 2, p. 37.

Proposition 2. *In the equilibria of the games Γ^i we have: $x^* \leq t^*$ and $\mathbf{q}^{i*} \leq \mathbf{q}^{p*}$, and*

$$t^{2*} \leq \hat{t}^2, \quad \hat{t}^1 \leq t^{1*} \quad and \ if \quad \omega \leq \xi, \quad \mathbf{q}^{1*} \leq \mathbf{q}^{2*},$$

where the inequalities are strict if $\beta \neq \gamma$.

From Proposition 2 in the equilibria of the games Γ^i, CEO *ex post* share is higher than his *ex ante* share, see Figures 3 and 4, pp. 38 and 39. One can distinguish two sources of investment distortions in the games Γ^i. The first group is rooted in investment market and property allocation imperfections. It relates to market and technology structure (player outside options, monopoly power and production function); and ownership structure (the choice ownership allocation); the resulting investment distortions mimic the distortions of the game $\hat{\Gamma}^i$.

We focus on the second group of distortions, stemming from insecure property rights due to positive transaction costs. These distortions are driven by player reneging, which causes underinvestment due to divergence of *ex ante* and *ex post* incentives to invest ($x^* \neq t^*$), and due to the suboptimal choice of *ex ante* share ($t^{2*} \leq \hat{t}^2$ or $\hat{t}^1 \leq t^{1*}$) – a result of player concern by the magnitude of their reneging expenses.

Remark 2. *For any fixed $\mathbf{q}$, the CEO's and the investor's optimal reneging expenses are unique and respectively decreasing with β and γ.*

Proof. Follows from the proof of Theorem 2. □

Theorem 2, Propositions 1 and 2 and Remark 2 permit us to investigate how the equilibria of the games Γ^i change with parameters. As we suggest below, the observed increase of CEO reneging follows from the present-day technological and contractual parameters.

3. Effects of Contractual Institutions

As we suggested, player reneging costs proxy their contractual costs, or more precisely, *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. Clearly,

the difference of β and γ reflects that player resources differ. These resources could be relative information available to them, their relative ability to process this information; and financial, legal and organizational resources at their disposal. Technology and contractual system are interdependent.Thus, exogenous technological shift likely affects the parameters β and γ.

Proposition 3. *Let the games* $\Gamma(\mathbf{o^I})$ *and* $\Gamma(\mathbf{o^{II}})$ *differ only in* β, *and let* $\beta^I < \beta^{II}$. *Then, the equilibrium of* $\Gamma(\mathbf{o^{II}})$ *Pareto dominates the equilibrium of* $\Gamma(\mathbf{o^I})$. *In equilibrium, the CEO's share is lower, and project value higher in* $\Gamma(\mathbf{o^{II}})$ *than in* $\Gamma(\mathbf{o^I})$.

Proof. See Appendix. □

When $\beta^I > \beta^{II}$ the CEO is better off, despite the fact that his equilibrium share is lower. 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 also inconsistent with claims that state corporate law is uniform or trivial.

Proposition 4. *Let the games* $\Gamma(\mathbf{o^I})$ *and* $\Gamma(\mathbf{o^{II}})$ *differ only in* γ, *and let* $\gamma^I < \gamma^{II}$. *Then, the equilibrium of the game* $\Gamma(\mathbf{o^I})$ *Pareto dominates the equilibrium of* $\Gamma(\mathbf{o^{II}})$. *In equilibrium, the CEO's share is lower, and project value higher in* $\Gamma(\mathbf{o^I})$ *than in* $\Gamma(\mathbf{o^{II}})$.

Proof. See Appendix. □

From Proposition 3, player equilibrium payoffs in the game Γ increase with β. Interestingly, from Proposition 4, an increase in γ has a reverse effect on player equilibrium payoffs. The intuition of this result is transparent if β and γ are interpreted as reflecting player relative bargaining powers, with lower β corresponding to higher bargaining power. From $\beta \leq \gamma$, investor bargaining power is lower than the CEO's, and, from Proposition 4, further reduction of investor bargaining power adversely affects both players. From Proposition 3, equilibrium surplus increases

with β. The surplus is the highest when β reaches γ, and player reneging costs get equal.

At the first glance, Propositions 3 and 4 should not hold simultaneously. In fact, Proposition 4 does not hold in the game Γ^p: it holds when $i = 1$ or 2 only. The intuition is based at the proof of Theorem 2. Consider the subgame Γ_x of the game Γ, in which x is fixed. At every fixed CEO's share, or at every game Γ_x, investor reneging expenses decrease with γ, see Remark 2. If social planner employs the same equilibrium share in the game $\Gamma(\mathbf{o^{II}})$ as in the game $\Gamma(\mathbf{o^I})$, the surplus would be higher in the game $\Gamma(\mathbf{o^{II}})$, because for any x, the *ex post* distortion [distance between t and x] is smaller, and *ex ante* share in the game Γ^p is optimal.

From the proof of Proposition 4, in the games $\Gamma(\mathbf{o^{II}})$ with $i = 1$ or 2, the distortion stemming from *ex post* share suboptimality is smaller and the distortion stemming from higher reneging expenses due to a lower γ is bigger, than in the game $\Gamma(\mathbf{o^{II}})$ but the latter effect dominates.

4. Comparative Analysis

Next, we investigate how parameters of the game Γ^i affect its equilibrium. To simplify the exposition, focus on the game Γ^1, and drop the superscript 1, thus denoting it by Γ.

We interpret μ as a characteristic of technology. Higher constants μ, ξ, or ω imply, respectively, more advanced technology, or higher investor or CEO outside option. We compare the equilibria of the games Γ which differ by technologies or outside options.

Proposition 5. *Let the games $\Gamma(\mathbf{o^I})$ and $\Gamma(\mathbf{o^{II}})$ differ only in μ, and let $\mu^I > \mu^{II}$. Then, in equilibrium, the CEO's share and project value is higher, and investments lower in $\Gamma(\mathbf{o^I})$ than $\Gamma(\mathbf{o^{II}})$.*

Proof. Analogous to Proposition 4. □

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 commitment conflict. 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. *Let the games $\Gamma(\mathbf{o}^{\mathbf{I}})$ and $\Gamma(\mathbf{o}^{\mathbf{II}})$ differ only in ω, and let $\omega^I < \omega^{II}$. Then, in equilibrium, investments are higher and the CEO's share lower in $\Gamma(\mathbf{o}^{\mathbf{I}})$ than $\Gamma(\mathbf{o}^{\mathbf{II}})$.*

Proof. Analogous to Proposition 4. $\qquad\qquad\qquad\qquad\qquad\qquad\square$

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. We suggest that the CEO's outside option ω can be instrumented by the level of executive compensation, which 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.

Proposition 7. *Let the games $\Gamma(\mathbf{o}^{\mathbf{I}})$ and $\Gamma(\mathbf{o}^{\mathbf{II}})$ differ only in ξ, and let $\xi^I < \xi^{II}$. Then, in equilibrium, investments and the CEO's share are higher in $\Gamma(\mathbf{o}^{\mathbf{I}})$ than $\Gamma(\mathbf{o}^{\mathbf{II}})$.*

Proof. Analogous to Proposition 4. $\qquad\qquad\qquad\qquad\qquad\qquad\square$

In general, data provides that the players' 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 Γ are likely endogenous. In reality, these parameters may change simultaneously. For example, historically, technology advancement (an increase in μ) has been accompanied by the advancement of the contractual mechanism (an increase in β and γ); similarly, historically, player outside options improve with technology as well. These empirical regularities clearly violate the condition of Propositions 3 - 7 that all other parameters are fixed.

5. Modified Games

Non-Zero Sunk Cost of Reneging

Our results generalize to the case of non-zero transaction costs. Let Γ_b^i denote the game Γ^i, in which the reneging cost function has a sunk cost. Let B_b be the reneging cost function in the game Γ_b^i:

$$B_b(v) = b + B(v) : \forall v \in (0, \infty),$$

and $b \geq 0$ is a constant. Then, b is a sunk cost of reneging:

$$\lim_{v \to 0} B_b(v) = b \geq 0.$$

Let Δ^* denote investor gain from choosing reneging over non reneging when investment in the game Γ^i is equal to $\mathbf{q}^{i*}$:

$$\Delta^* = p\Phi(\mathbf{q}^*) - \gamma B(s^*),$$

Remark 3. *For any $b < \Delta^*$ the equilibrium of the game Γ_b^i is the same as of Γ^i.*[9]

Proof. Follows from the proofs of Theorems 1 and 2. $\square$

The Game $\mathfrak{T}$

Definition 2. *Let $\mathfrak{T}_b^i$ denote the game Γ_b^i, with an additional requirement: reneging in the game $\mathfrak{T}^i$ occurs only if at least one player announces his intent to renege ex ante contract.*

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[9]Schwartz (2000) shows that Theorem 2 holds for any $b \in [0, \infty)$.

If such an announcement occurs, players choose their *ex post* actions simultaneously and independently, and the game $\mathfrak{T}_b$ coincides with Γ_b. In the absence of the announcement, the surplus is divided between the players in accordance with the *ex ante* contract. Then, in the equilibrium of the game $\mathfrak{T}_b$ player reneging expenses are zero, and the equilibria of the games $\mathfrak{T}_b$ and $\hat{\Gamma}$ coincide.

In the equilibrium of the game $\mathfrak{T}$ reneging occurs only when the CEO's net gain from reneging is positive, while in the equilibrium of the game Γ_b reneging could occur even when both players lose from reneging.

Theorem 3. *An equilibrium of the game $\mathfrak{T}_b^i$ exists, and is unique. For any finite β and γ, there exists $\bar{b} \geq 0$ such that the equilibrium of $\mathfrak{T}_b^i$ is the same as in $\hat{\Gamma}^i$ if $b \geq \bar{b}$, and as in Γ_b^i if $b < \bar{b}$.*

Proof. See Appendix (Follows from the proofs of Theorems 1 and 2). $\square$

From Theorem 2, in the game Γ^i investment distortion disappears when $\beta = \gamma$ and player outside options approach zero, but their equilibrium payoffs are below their game $\hat{\Gamma}^i$ payoffs due to the dissipation of surplus on reneging expenses.

From Theorem 3, when equilibrium reneging expenses in the game $\mathfrak{T}_b$ are zero, players may achieve their equilibrium payoffs of the game $\hat{\Gamma}$ in the equilibrium of $\mathfrak{T}_b$. In this case, player payoffs are unaffected by imperfections of contractual system, and player equilibrium surplus is the same as with zero transaction costs, i.e., as in the game $\hat{\Gamma}$.

Remark 4. *If $\beta = \gamma$ the equilibrium of the game $\mathfrak{T}$ does not depend on player reneging costs.*

Proof. Follows from the proofs of Theorems 1 – 3. $\square$

From Remark 4, when player equilibrium reneging expenses are equal, even poorly working contractual institutions (low β) permit to sustain the game $\hat{\Gamma}$ equilibrium in the game $\mathfrak{T}$. From Theorem 3 and Remarks 2 and 4, for any fixed sunk cost b, the equilibria of the games $\hat{\Gamma}$ and $\mathfrak{T}$ are more likely to coincide when player reneging costs are similar. Thus, we infer that player similarity mitigates contractual inefficiencies. There are two possibilities to make the gap between β and γ smaller: by an increase of β or by a decrease of γ. From Propositions 3 and 4, and Remark 2, making β higher is more attractive.

We regard the game $\mathfrak{T}$ to be more realistic than Γ. It is likely that players would

switch to the game $\mathfrak{T}$, because it Pareto dominates Γ. Next, we suggest another modification of the game Γ, which permits players to achieve equilibrium payoffs even higher than in the game $\mathfrak{T}$.

The Game G

Definition 3. *Let G^i denote the game derived from the game Γ_b^i (or $\mathfrak{T}_b^i$) by subtracting the investor's reneging costs from player objectives.*

From Definition 3, player objectives in the game G^i are:

$$W(\mathbf{a}) = t\Phi(\mathbf{q}) - D(r,s) - \omega q_1, \qquad D(r,s) = \beta B(r) - \gamma B(s),$$

$$\Pi(\mathbf{a}) = (1-t)\Phi(\mathbf{q}) - \xi q_2, \qquad \mathbf{a} = (x,r,s,\mathbf{q}), \qquad \Phi(\mathbf{q}) = P(F(\mathbf{q})),$$

where the function D denotes the CEO's costs of reneging in the game G^i. The investor in the game G^i cannot renege. In all other respects the game G^i is identical to the game Γ^i (or $\mathfrak{T}^i$). The game G^i has the following order of moves: first, player i chooses x, second, players simultaneously and independently make their investments q_1 and q_2, and third (*ex post*) the CEO chooses r and s. The project's surplus is divided between the players, with the CEO's share equal to t, and investor share – to $(t-1)$. From Definition 3 and the proofs of Theorems $1-3$, we have:

Theorem 4. *An equilibrium of the game G^i exists, and is unique. In the equilibrium of the game G^i, each player receives at least his game $\mathfrak{T}^i$ payoff.*

Comparative analysis of the games G and $\mathfrak{T}$ which differ in one of the parameters is analogous to the analysis for the game Γ.

6. 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 β, 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 β and γ due to a decrease in β, not accompanied by a matching decrease in γ. We show that with costly contracts, the hold-up problem is less acute when players reneging costs are similar (Theorem 3 and Remark 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 advancement of production technology (an increase in μ), decrease of outside options (a decrease in investment returns (ξ) and executive compensation (ω)), and effects of technological changes on contractual mechanism (decrease in β and γ, and increase in their disparity), see Propositions 5, 6 - 7, and 3 – 6, respectively.

Making specific conclusions about the underlying changes of parameters causing an increase of CEO reneging requires further theoretical modelling and data analysis. One need not address the specifics of parameter changes to infer from the pattern of CEO reneging that investment distortions worsened. 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.

The ideas expressed herein, agree with empirical results of Himmelberg et. al. (1999), Demsetz and Villalonga (2001), and Palia (2001) who find no statistically significant relation between ownership structure and firm performance, if ownership is made multi-dimensional and also is treated as an endogenous variable.

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Proofs

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 interval. At the boundary points the left or the right limit of the function is considered.

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

$$t\Phi'(\mathbf{q}) - \omega = 0, \quad \mathbf{q} = (q_1, q_2) \tag{4}$$

$$(1-t)\Phi'(\mathbf{q}) - \xi \geq 0 \tag{5}$$

$$q_1 = q_2 \geq 0, \tag{6}$$

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

$$t\Phi'(\mathbf{q}) - \omega \geq 0, \quad \mathbf{q} = (q_1, q_2) \tag{7}$$

$$(1-t)\Phi'(\mathbf{q}) - \xi = 0, \tag{8}$$

$$q_1 = q_2 \geq 0, \tag{9}$$

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

$$\check{t} = \frac{\omega}{\omega + \xi}, \quad \text{and} \quad \Phi'(\hat{\mathbf{q}}(\check{t})) = \omega + \xi, \tag{10}$$

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

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

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

Step 2. Let $\hat{\Gamma}^i(t)$, with $i = 1, 2$, or p, denote a subgame of the game $\hat{\Gamma}^i$ which starts with a fixed $t \in [0, 1]$. There exists an equilibrium of the game $\hat{\Gamma}^i(t)$. The equilibrium is unique and player investments are $\hat{\mathbf{q}}(t) = (\hat{q}(t), \hat{q}(t))$, where $\hat{\mathbf{q}}(t)$ is a solution of the system of equations (4) – (6).

Proof of Step 2: Let $\tilde{\mathbf{q}}^i(t) = (\tilde{q}_1^i(t), \tilde{q}_2^i(t))$ 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 $\tilde{q}_1^i(t) = \tilde{q}_1^i(t)$, and equation (6) holds in any equilibrium. From player optimization and from Pareto 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, $\tilde{\mathbf{q}}^i(t) = \hat{q}(t)$ and Step 2 is proven. $\square$

Step 3: There exists a unique equilibrium of the game $\hat{\Gamma}^p$, and equilibrium actions are $(\hat{\mathbf{q}}^p, \hat{t}^p)$, 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:

$$T(t) = \max_{t \in [0,1]} \left[\Phi(\hat{\mathbf{q}}(t)) - (\omega + \xi)\hat{q}(t) \right].$$

Since $T(0) = T(1) = 0$, in any equilibrium of the game $\hat{\Gamma}^p$ we have $t \in (0,1)$ because $T(t) > 0$ for any $t \in (0,1)$. From the social planner optimization in any equilibrium:

$$A(t)\frac{d\hat{q}(t)}{dt} = 0, \quad \text{where} \quad \hat{A}(t) = \left[\Phi'(\hat{\mathbf{q}}(t)) - (\omega + \xi) \right]. \tag{12}$$

From differentiation of equation (11) with respect to t:

$$\frac{d\hat{q}(t)}{dt} = \begin{cases} -\frac{\omega}{t^2 \Phi''(\hat{\mathbf{q}}(t))} = -\frac{[\Phi'(\hat{\mathbf{q}}(t))]^2}{\omega \Phi''(\hat{\mathbf{q}}(t))} > 0 : \forall t \in [0,\check{t}) \\ \frac{\xi}{(1-t)^2 \Phi''(\hat{\mathbf{q}}(t))} = \frac{[\Phi'(\hat{\mathbf{q}}(t))]^2}{\xi \Phi''(\hat{\mathbf{q}}(t))} < 0 : \forall t \in (\check{t},1] \end{cases}, \tag{13}$$

Thus, the derivative $\frac{d\hat{q}(t)}{dt} \neq 0$, and in any equilibrium of the game $\hat{\Gamma}^p$:

$$\Phi'(\hat{\mathbf{q}}(t)) - \omega + \xi = 0 \tag{14}$$

which holds at $t = \check{t}$ only, see equation (10). Thus, the game $\hat{\Gamma}^p$ has a unique equilibrium, and Step 3 is proven. $\qquad\square$

Step 4. There exist a unique equilibrium in each game $\hat{\Gamma}^i$, with $i = 1, 2$, and we have:

$$\tilde{t}^2 \leq \hat{t}^p \leq \hat{t}^1 \quad \text{and} \quad \hat{\mathbf{q}}^i = \hat{\mathbf{q}}(\hat{t}^i) \leq \hat{\mathbf{q}}^p. \tag{15}$$

Proof of Step 4. Our proof is by contradiction. Let the outcome $\tilde{\mathbf{o}}$ with actions $(\tilde{t}, \tilde{\mathbf{q}})$, $\tilde{t} < \check{t}$ be an equilibrium of the game $\hat{\Gamma}^1$. From Lemma 1, there exists an outcome $\check{\mathbf{o}}$, with actions $(\check{t}, \check{\mathbf{q}})$, in which $\check{\mathbf{q}} = \tilde{\mathbf{q}}$ and $\check{t}_1 > \check{t}$. Since the CEO's payoff in $\check{\mathbf{o}}$ is higher than in $\tilde{\mathbf{o}}$, the outcome $\tilde{\mathbf{o}}$ 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:

$$\hat{\Gamma}^1: \quad \hat{V}(t) = \max_{t \in [\check{t},1]} \left[t\Phi(\hat{q}(t)) - \omega\hat{q}(t) \right], \tag{16}$$

$$\hat{\Gamma}^2: \quad \hat{\Pi}(t) = \max_{t \in [0,\check{t}]} \left[(1-t)\Phi(\hat{q}(t)) - \xi\hat{q}(t) \right]. \tag{17}$$

Thus, in equilibria of the games $\hat{\Gamma}^1$ and $\hat{\Gamma}^2$ we have:

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

$$\hat{\Gamma}^2: \quad \hat{\Pi}'(t) = \frac{d\hat{q}(t)}{dt}\hat{A}(t) - \Phi(\hat{\mathbf{q}}(t)) = 0, \quad \text{where} \quad t \in [0, \check{t}],$$

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

$$\hat{\Gamma}^1: \quad \hat{V}''(t) = \frac{d^2\hat{q}(t)}{dt^2}\hat{A}(t) + \underset{[-]}{\frac{d\hat{q}(t)}{dt}}\left[\underset{[-]}{\Phi'(\hat{\mathbf{q}}(t))} + \Phi''(\hat{\mathbf{q}}(t))\underset{[-]}{\frac{d\hat{q}(t)}{dt}}\right] < 0 : \forall t \in (\check{t}, 1],$$

$$\hat{\Gamma}^2: \quad \hat{\Pi}''(t) = \frac{d^2\hat{q}(t)}{dt^2}\hat{A}(t) + \underset{[+]}{\frac{d\hat{q}(t)}{dt}}\left[-\underset{[-]}{\Phi'(\hat{\mathbf{q}}(t))} + \Phi''(\hat{\mathbf{q}}(t))\underset{[+]}{\frac{d\hat{q}(t)}{dt}}\right] < 0 : \forall t \in [0, \check{t}],$$

because from twice differentiation of equation (11) with respect to t the derivative $\frac{d^2\hat{q}(t)}{dt^2}$ is negative for any $t \in [0, 1]$:

$$\frac{d^2\hat{q}(t)}{dt^2} = \begin{cases} -\underset{[+]}{\frac{d\hat{q}(t)}{dt}}\frac{1}{\omega} \times \left[2\left[\Phi'\right]^2 - \left[\frac{\Phi'}{\Phi''}\right]^2\underset{[-]}{\Phi'''}\right] < 0 : \forall t \in [0, \check{t}) \\ \underset{[-]}{\frac{d\hat{q}(t)}{dt}}\frac{1}{\xi} \times \left[2\left[\Phi'\right]^2 - \left[\frac{\Phi'}{\Phi''}\right]^2\underset{[-]}{\Phi'''}\right] < 0 : \forall t \in (\check{t}, 1] \end{cases}.$$

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

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 Γ^i with $i = 1, 2$ or p, see for example, Fudenberg and Tirole, (1991).

Lemma 1. Consider the following system of equations

$$[1 - x - (r - s)]\, \Phi'(\mathbf{q}) - \xi = 0, \quad \mathbf{q} = (q_1, q_2) \tag{18}$$

$$[x + r - s]\, \Phi'(\mathbf{q}) - \omega \geq 0, \tag{19}$$

$$\Phi(\mathbf{q}) - \beta B'(r) = 0, \tag{20}$$

$$\Phi(\mathbf{q}) - \gamma B'(s) = 0, \tag{21}$$

$$q_1 = q_2 \geq 0, \tag{22}$$

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

$$\check{x} = \frac{\omega}{\omega + \xi} - [\check{r} - \check{s}]\,,$$

and $\check{\mathbf{q}} = \mathbf{q}(\check{x})$, $\check{r} = r(\check{x})$ and $\check{s} = s(\check{x})$ are solutions of:

$$\Phi'(\check{\mathbf{q}}) = \omega + \xi, \quad \text{and} \quad \Phi(\check{\mathbf{q}}) = \beta B'(\check{r}) \quad \text{and} \quad \Phi(\check{\mathbf{q}}) = \gamma B'(\check{s}),$$

which are unique from the properties of the functions Φ and B. Let

$$t(x) = x - r(x) + s(x).$$

Then, it is clear that the system of equations $(18) - (20)$ is exactly the system $(4) - (6)$. We have $t(\check{x}) = \check{t}$ and $\check{\mathbf{q}} = \hat{\mathbf{q}}^p$ because $\mathbf{q}(x) = \hat{\mathbf{q}}(t(x))$ for any $x \in [\check{x}, 1]$.

Proof of Lemma 1: When $x \in [0, \check{x})$, from equation (18) we have

$$\Phi'(\mathbf{q}) < \omega + \xi,$$

and from equation (19):

$$\Phi'(\mathbf{q}) > \omega + \xi,$$

which is a contradiction, thus, no solution of the system of equations $(18) - (22)$ exists for $x \in [0, \check{x})$.

Keep x and $\mathbf{q} = (q, q)$ 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 Φ and B, there exist a unique solution of each equation (20) and (21) for any fixed x and $\mathbf{q} = (q, q)$, $q \in [0, \infty)$. Let $r^{\mathbf{q}}(x)$ and $s^{\mathbf{q}}(x)$ denote these solutions, respectively. Differentiation of equations (20) and (21) with respect to q, when x is fixed, gives us the derivatives $\frac{dr^{\mathbf{q}}(x)}{dq}$ and $\frac{ds^{\mathbf{q}}(x)}{dq}$:

$$\left. \frac{dr^{\mathbf{q}}(x)}{dq} \right|_{x=const} = \left. \frac{\Phi'(q)}{\beta B''(r^{\mathbf{q}}(x))} \right| > 0, \quad \left. \frac{ds^{\mathbf{q}}(x)}{dq} \right|_{x=const} = \left. \frac{\Phi'((q)}{\gamma B''(s^{\mathbf{q}}(x))} \right| > 0.$$

Thus, for a fixed x, the derivative of equation (18) with respect to q is negative:

$$(1 - x - r + s)\Phi''(\mathbf{q}) - \left[\frac{1}{\beta B''(r^{\mathbf{q}}(x))} - \frac{1}{\gamma B''(s^{\mathbf{q}}(x))} \right] \Phi'(\mathbf{q}) < 0 : \forall x \in [\check{x}, 1]$$

due to the properties of the functions B and Φ.

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

$$\lim_{\mathbf{q} \to 0} \left[1 - x - r + s \right] \Phi'(\mathbf{q}) - \xi > 0$$

is positive. Thus, a unique interior solution of equation (18) exists, which we denote by $q(x)$. From uniqueness and existence of $r^{\mathbf{q}}(x)$, $s^{\mathbf{q}}(x)$ and $q(x)$, there exist a unique $r(x) = r^{q(x)}(x)$, and a unique $s(x) = s^{q(x)}(x)$ and, thus, a unique solution of the system of equations (18) – (22). This solution $(\mathbf{q}(x), r(x), s(x))$ is continuous and twice continuously differentiable from the properties of the underlying functions, and Lemma 1 is proven. $\qquad \square$

Step 2: Let the outcome $\mathbf{o}^*$ with actions $(x^*, \mathbf{q}^*, s^*, r^*)$ and $x^* \in [0, \check{x})$ be an equilibrium of the game Γ^i. Then, $\mathbf{q}^* < \check{\mathbf{q}}$, and at $x = x^*$ we have:

$$\left. \frac{dq}{dx} \right|_{x=x^*} = \frac{1}{\left\{ -\frac{\Phi''\omega}{[\Phi']^2} - \frac{\Phi'}{\Phi} \left[\frac{B'(r^*)}{B''(r^*)} - \frac{B'(s^*)}{B''(s^*)} \right] \right\}}, \tag{23}$$

where $\Phi = \Phi(\mathbf{q}^*), \Phi' = \Phi'(\mathbf{q}^*), \Phi'' = \Phi''(\mathbf{q}^*)$, and r^* and s^* are solutions of

$$\Phi(\mathbf{q}^*) = \beta B'(r) \quad \text{and} \quad \Phi(\mathbf{q}^*) = \gamma B'(s). \tag{24}$$

Proof of Step 2: Since the system of equations (18) – (22) has no solution for $x \in [0, \check{x})$, in any equilibrium of the game Γ^i with $x^* \in [0, \check{x})$:

$$[x^* + r^* - s^*] \Phi'(\mathbf{q}^*) - \omega = 0 \tag{25}$$

for efficiency. Also for efficiency, equations (20) – (22) hold, and $\mathbf{q}^* < \check{\mathbf{q}}$ follows immediately. Equation (23) follows from differentiation of equations (24) and (25)
. □

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

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

Step 4. In any equilibrium of the game Γ^p the actions $(\mathbf{q}^{p*}, s^{p*}, r^{p*})$ are identical (only x could differ across equilibria of Γ^p). There exist two equilibria of the game Γ^p: a unique equilibrium with the CEO's share belonging to $[\check{x}, 1]$, and a unique equilibrium his share belonging to $[0, \check{x}]$.

Proof of Step 4: Social planner objective is

$$S(\mathbf{a}) = \max_x \left[\Phi(\mathbf{q}) - (\xi + \omega)q - \beta_1 B(r) - \gamma B(s) \right].$$

From Step 2 and social planner optimization, in the equilibrium of the game Γ^p the following equation holds:

$$\left\{ \left[1 - \left[\frac{B'(r^{p*})}{B''(r^{p*})} + \frac{B'(s^{p*})}{B''(s^{p*})} \right] \right] \Phi'(\mathbf{q}^{p*}) - [\xi + \omega] \right\} \times \left. \frac{dq}{dx} \right|_{x=x^{p*}} = 0 : x = x^{p*},$$

because from equation (24) at any equilibrium share x^{p*}:

$$\left. \frac{dr}{dx} \right|_{x=x^{p*}} = \left. \frac{dr}{dq} \right|_{q=q^{p*}} \times \left. \frac{dq}{dx} \right|_{x=x^{p*}} = \frac{\Phi'(\mathbf{q})}{\beta B''(r^{\mathbf{q}})} \left. \frac{dq}{dx} \right|_{x=x^{p*}},$$

$$\left. \frac{ds}{dx} \right|_{x=x^{p*}} = \left. \frac{ds}{dq} \right|_{q=q^{p*}} \times \left. \frac{dq}{dx} \right|_{x=x^{p*}} = \frac{\Phi'(\mathbf{q})}{\gamma B''(s^{\mathbf{q}})} \left. \frac{dq}{dx} \right|_{x=x^{p*}}.$$

From equation (23) $\left. \frac{dq}{dx} \right|_{x=x^{p*}} \neq 0$, thus, in any equilibrium of the game Γ^p:

$$\left\{ \left[1 - \left[\frac{B'(r^{p*})}{B''(r^{p*})} + \frac{B'(s^{p*})}{B''(s^{p*})} \right] \right] \Phi'(\mathbf{q}^{p*}) - [\xi + \omega] \right\} = 0. \tag{26}$$

From Step 2 and equation (26), in all equilibria of the game Γ^p the actions $(\mathbf{q}^{p*}, s^{p*}, r^{p*})$ are identical.

From Lemma 1, there exists a unique $x \in [\check{x}, 1]$, such that equation (26) holds. Thus, there exists a unique equilibrium of the game Γ^p with CEO share belonging to $[\check{x}, 1]$. Let $x^{p*1} \in [\check{x}, 1]$ be the equilibrium share. Then, $\mathbf{q}^{p*} = \mathbf{q}(x^{p*1}), s^{p*} = s(x^{p*1})$, and $r^{p*} = r(x^{p*1})$.

Since there exists only one $x^{p*2} \in [0, \check{x})$ that solves equation (25):

$$[x + r^{p*} - s^{p*}] \, \Phi'(\mathbf{q}^{p*}) - \omega = 0,$$

there exists a unique equilibrium of the game Γ^p with $x^{p*2} \in [0, \check{x})$. Thus, there exist two equilibria of the game Γ^p, and Step 4 is proven. □

Step 5. Let x^{1*} and x^{2*} be CEO *ex ante* shares in some equilibria of the games Γ^1 and Γ^2. Then:

$$x^{2*} \leq \check{x} \leq x^{1*}. \tag{27}$$

Proof of Step 5: Analogous to the proof of equation (15), see Step 4 of Theorem 1. □

Step 6. There exists a unique equilibrium in the game Γ^1.

Proof of Step 6: From Lemma 1 and equation (27), in any equilibrium of the game Γ^1 we have $x \in [\check{x}, 1]$, and player objectives can be expressed as functions of x:

$$\mathring{V}(x) = V(x, \mathbf{q}(x), r(x), s(x)) : \forall x \in [\check{x}, 1]$$
$$\mathring{\Pi}(x) = \Pi(x, \mathbf{q}(x), r(x), s(x)) : \forall x \in [\check{x}, 1],$$

and player surplus as the function of x is:

$$\mathring{S}(x) = \mathring{V}(x) + \mathring{\Pi}(x).$$

In any equilibrium of the game Γ^1:

$$\mathring{V}'(x) = 0.$$

For any $x \in [\check{x}, 1]$ equilibrium profit $\mathring{\Pi}(x)$ of the game $\Gamma^i(x)$ decreases with x:

$$\mathring{\Pi}'(x) < 0. \tag{28}$$

From Step 3, in the equilibrium of the game $\Gamma^i(x)$, with $x \in [\check{x}, x^{p*1}]$, we have:

$$\mathring{S}'(x) = \underset{[-]}{\mathring{\Pi}'(x)} + \mathring{V}'(x) > 0 : x \in [\check{x}, x^{p*1}],$$

because

$$\mathring{S}'(x) = \left[A(x) - \left[\frac{B'(r(x))}{B''(r(x))} + \frac{B'(s(x))}{B''(s(x))} \right] \Phi'(\mathbf{q}(x)) \right] \times \frac{dq(x)}{dx} = \begin{cases} > 0 : x \in [\check{x}, x^{p*1}] \\ < 0 : x \in [x^{p*1}, 1] \end{cases}, \tag{29}$$

where

$$A(x) = \Phi'(\mathbf{q}(x)) - [\xi + \omega].$$

Thus, from equations (28) and (29):

$$\mathring{V}'(x) > 0 \quad \text{for} \quad x \in [\check{x}, x^{p*1}],$$

and $x \in [\check{x}, x^{p*1}]$ cannot be an equilibrium of the game Γ^1, in which case we have:

$$\mathbf{q}^{1*} < \mathbf{q}^{p*},$$

because from equations (18), (20) and (21) $\frac{dq(x)}{dx} < 0$ for $x \in (\check{x}, 1]$:

$$\frac{dq(x)}{dx} = \frac{1}{\left\{ \frac{\Phi''(\mathbf{q}(x))\xi}{[\Phi'(\mathbf{q}(x))]^2} - \frac{\Phi'(\mathbf{q}(x))}{\Phi(\mathbf{q}(x))} \left[\frac{B'(r(x))}{B''(r(x))} - \frac{B'(s(x))}{B''(s(x))} \right] \right\}} < 0 : \forall x \in (\check{x}, 1]. \qquad (30)$$

Let there exists two equilibria of the game Γ^1, with actions $(\dot{x}, \dot{q}, \dot{r}, \dot{s})$ and $(\ddot{x}, \ddot{q}, \ddot{r}, \ddot{s})$. From Step 3 an equilibrium originating at any x is unique, so $\dot{x} \neq \ddot{x}$. For efficiency, the surplus in all equilibria of the game Γ^1 is equal:

$$\mathring{S}(\dot{x}) = \mathring{S}(\ddot{x}),$$

which cannot hold because from equation (29)

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

and we have shown that in any equilibrium, CEO *ex ante* shares, $\dot{x}$ and $\ddot{x}$, belong to $[x^{p*1}, 1]$. Thus, equilibrium of the game Γ^1 is unique, and Step 7 is proven. $\square$

Step 7. There exists a unique equilibrium of the game Γ^2.

Proof of Step 7: Analogous to Step 6, and Theorem 2 is proven. $\square$

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

$$\hat{\Gamma}^1: \quad \hat{V}'(t) = \frac{[\Phi'(\hat{\mathbf{q}}(t))]^2}{\xi \Phi''(\hat{\mathbf{q}}(t))} \hat{A}(t) + \Phi = \begin{cases} > 0 : \forall t \in [\check{t}, \hat{t}^1) \\ < 0 : \forall t \in (\hat{t}^1, 1] \end{cases},$$

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

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

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

and since the function $\hat{V}'$ decreases with t, we have $\hat{t}^1 \geq \tilde{t}$, and $\hat{\mathbf{q}}^1 = \hat{\mathbf{q}}(\hat{t}^1) \leq \hat{\mathbf{q}}^2$ follows from equation (13). Since for any $\mathbf{q} < \hat{\mathbf{q}}^p$ equilibrium surplus increases with $\mathbf{q}$, 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. $\qquad\square$

Proof of Proposition 2. From equations (14) and (26):

$$\mathbf{q}^{p*} \leq \hat{\mathbf{q}}^p,$$

and from the proof of Theorem 2:

$$\mathbf{q}^{2*} < \mathbf{q}^{p*} \quad \text{and} \quad \mathbf{q}^{1*} < \mathbf{q}^{p*}$$

and

$$x^{2*} \leq \check{x} < x^{p1*} < x^{1*} \quad \text{and} \quad t^{2*} \leq \check{t} < t^{p1*} < t^{1*},$$

where $t^{i*} = x^{i*} + r^{i*} - s^{i*}$.

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

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

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

$$\mathring{V}'(x) = \frac{dq(x)}{dx}V1(x) : \forall x \in [x^{1*}, 1], \tag{31}$$

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

$$V1(x) = \left\{\left[1 - \frac{B'(r(x))}{B''(r(x))}\right]\Phi'(\mathbf{q}(x)) - [\omega + \xi] + \frac{\Phi''\xi}{[\Phi']^2}\right\} < 0 : \forall x \in [x^{1*}, 1]$$

or as:

$$\mathring{V}'(x) = \frac{dq(x)}{dx} V1(x) + \Phi(\mathbf{q}(x)) : \forall x \in [x^{1*}, 1], \tag{32}$$

where $V2(x)$ is:

$$V2(x) = \left\{ \left[1 - \frac{B'(s(x))}{B''(s(x))} \right] \Phi'(\mathbf{q}(x)) - [\omega + \xi] \right\} > 0 : \forall x \in [x^{1*}, 1],$$

In the game Γ^2 we have $x^{2*} \in [0, \check{x}]$, and the following equation holds in equilibrium:

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

or

$$\frac{d\Pi}{dx}\bigg|_{x=x^{2*}} = \frac{dq}{dx}\bigg|_{x=x^{2*}} \left\{ \left[1 - \frac{B'(s)}{B''(s)} \right] \Phi'^* - \frac{\Phi''^* \omega}{[\Phi'^*]^2} - - [\omega + \xi] \right\} = 0,$$

where $\frac{dq}{dx}\big|_{x=x^{2*}}$ is given by equation (23), and for brevity $\Phi = \Phi(\mathbf{q}^{2*})$, $B(r) = B(r^{2*})$, $B(s) = B(s^{2*})$, etc. Next, we calculate:

$$\frac{\mathring{V}'(x)}{\frac{dq(x)}{dx}}\bigg|_{x=\tilde{x}} - \frac{d\Pi}{dx} \frac{1}{\frac{dq}{dx}}\bigg|_{x=x^{2*}} = \left[\frac{B'(r)}{B''(r)} - \frac{B'(s)}{B''(s)} \right] \Phi' + \left[\frac{\Phi}{\frac{dq(x)}{dx}\big|_{x=\tilde{x}}} + \frac{\Phi}{\frac{dq}{dx}\big|_{x=x^{2*}}} \right]$$

$$\frac{1}{\frac{dq(x)}{dx}\big|_{x=\tilde{x}}} + \frac{1}{\frac{dq}{dx}\big|_{x=x^{2*}}} = \frac{\Phi'' \xi}{[\Phi']^2} - \frac{\Phi'}{\Phi} \left[\frac{B'(r)}{B''(r)} - \frac{B'(s)}{B''(s)} \right] - \frac{\Phi'' \omega}{[\Phi']^2} - \frac{\Phi'}{\Phi} \left[\frac{B'(r)}{B''(r)} - \frac{B'(s)}{B''(s)} \right]$$

$$= \frac{\Phi'' [\xi - \omega]}{[\Phi']^2} - \frac{2\Phi'}{\Phi} \left[\frac{B'(r)}{B''(r)} - \frac{B'(s)}{B''(s)} \right] < 0$$

$$\frac{\mathring{V}'(x)}{\frac{dq(x)}{dx}}\bigg|_{x=\tilde{x}} - \frac{d\Pi}{dx} \frac{1}{\frac{dq}{dx}}\bigg|_{x=x^{2*}} = \left[\frac{B'(s)}{B''(s)} - \frac{B'(r)}{B''(r)} \right] \Phi' + \frac{\Phi \Phi''}{[\Phi']^2} [\xi - \omega] < 0 \quad \text{if} \quad \omega \le \xi.$$
$$\underset{[-]}{}$$

From our calculation:

$$\mathring{V}'(\tilde{x}) > 0 \quad \text{if} \quad \omega \le \xi,$$

thus:

$$\mathbf{q}^{1*} \le \mathbf{q}^{2*} \quad \text{if} \quad \omega \le \xi,$$

in which case

$$\mathbf{q}^{1*} < \mathbf{q}^{2*} < \mathbf{q}^{p*} < \hat{\mathbf{q}}^{p} \quad \text{if } \xi = \omega \quad \text{and} \quad \beta < \gamma.$$

Since for any $\mathbf{q} < \mathbf{q}^{p*}$ equilibrium surplus increases with $\mathbf{q}$, equilibrium surplus is higher in the game, where *ex ante* contract is chosen by a more *committed* player, and Proposition 2 is proven. $\qquad \square$

Proof of Proposition 3. **Notation and Preliminaries for the Proofs of Propositions $3 - 7$:** Let $(x^{I*}, \mathbf{q}^{I*}, r^{I*}, s^{I*})$ and $(x^{II*}, \mathbf{q}^{II*}, r^{II*}, s^{II*})$ denote player actions in the equilibria of $\Gamma^{I} = \Gamma(\mathbf{o^I})$ and $\Gamma^{II} = \Gamma(\mathbf{o^{II}})$. 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 $\mathbf{q}^{I}(\tilde{x}) = \mathbf{q}^{II}(x^{II*}) = \mathbf{q}^{II*}$, then:

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

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

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

From equation (32) we have:

$$\mathring{V}'^{I}(\tilde{x}) - \mathring{V}'^{II}(x^{II*}) = V2(x^{II*}) \left\{ \underbrace{\left.\frac{dq(x)}{dx}\right|_{x=\tilde{x}} - \left.\frac{dq^{II}(x)}{dx}\right|_{x=x^{II*}}}_{[+]} \right\} > 0,$$

because

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

thus, $\mathring{V}'(\tilde{x}) > 0$, 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 (30):

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

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

$$V^{I*} = \mathring{V}^{I}(x^{I*}) < \mathring{V}^{II}(\breve{x}),$$

because from the properties of the function B:

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

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

$$V^{I*} < \mathring{V}(\breve{x}) \leq V^{II*}.$$

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

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

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

Proof of Proposition 4. Let $\tilde{x}$ such that $\mathbf{q}^{I}(\tilde{x}) = \mathbf{q}^{II}(x^{II*}) = \mathbf{q}^{II*}$, then:

$$\Phi(x^{I}) = \Phi^{II*} = \gamma^{II} B'(s(\tilde{x})) = \gamma^{II} B'(s^{II*}),$$

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

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

$$V1(\tilde{x}) = V1(x^{II*}).$$

From equation (31) we have:

$$\mathring{V}'^{I}(\tilde{x}) - \mathring{V}'^{II}(x^{II*}) < \left\{ \left.\frac{dq^{I}(x)}{dx}\right|_{x=\tilde{x}} - \left.\frac{dq^{II}(x)}{dx}\right|_{x=x^{II*}} \right\} \times V1(x^{II*}) < 0,$$
$$\underset{[+]}{} \qquad\qquad\qquad\qquad \underset{[-]}{}$$

because

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

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

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

from which

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

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

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

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

because $x^{I*} < x^{II*}$. Thus, investor equilibrium profit is lower in the game Γ^{II} than in Γ^I, and Proposition 4 is proven. $\qquad\square$

Proof of Theorem 3. From the assumption of $\beta \leq \gamma$ and the proof of Theorem 2, in the equilibrium of the game Γ^i, net reneging gain is negative for the investor, and could have either sign for the CEO. Consider the game Γ^p with a fixed γ, and $\beta \in (0, \gamma]$, and let $R(\beta)$ denote the CEO's net gain from reneging at $\mathbf{q} = \hat{\mathbf{q}}^p$.[10] Clearly, $R(\beta)$ is negative for $\beta = \gamma$ only, and positive for any $\beta < \gamma$. Next, consider the game Γ_b^p, and define $R_b(\beta)$ as:

$$R_b(\beta) = R(\beta) - b,$$

which is the CEO's net gain from reneging at $\mathbf{q} = \hat{\mathbf{q}}^p$ in the game Γ_b^p. From Theorem 2, the functions R_b and R are continuous and decreasing in β, and $R_b(\beta)$ is negative at $\beta = \gamma$ for any $b \geq 0$, because

$$R_b(\beta) < R(\beta).$$

Let

$$\tilde{b} = R(\tilde{\beta}),$$

where $\tilde{\beta} \in (0, \gamma)$ and consider the games Γ^p and Γ_b^p with $\beta = \tilde{\beta}$. From Theorem 2 for any $b < \tilde{b}$ we have $R_b(\beta) > 0$, and for any $b > \tilde{b}$ we have $R_b(\beta) < 0$. The equilibrium of the game $\hat{\Gamma}^p$ is sustainable in $\mathfrak{T}_b^p$, with any $b \geq \tilde{b}$ and it is not sustainable when $b < \tilde{b}$ – exactly as Theorem 3 states, and Theorem 3 is proven. $\qquad\square$

---

[10]From our definition, $R(\beta) = (r^{p*} - s^{p*})\Phi^{p*} - \beta B(r^{p*})$

Table I

Search Words	Publications	Search Periods		
		06.01.01-10.31.01	01.01.02-05.31.02	06.01.02-10.31.02
Accounting & Scandal	WSJ	4	85	217
	NYT	5	115	292
	FT	5	89	352
Corporate & Fraud	WSJ	7	38	105
	NYT	10	35	136
	FT	7	18	158
Financial & Crime	WSJ	19	31	24
	NYT	39	28	40
	FT	133	190	131
Restore & Investor & Confidence	WSJ	12	17	51
	NYT	20	16	54
	FT	21	22	102
Total		282	684	1662

Table I presents the number of articles in the listed publications, with the search words in the title or abstract during the listed periods.[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.

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[11]WSJ, NYT and FT stand for Wall Street Journal, New York Times (NYT) and Financial Times (London). Each column (III, IV, V) covers six months, with dates listed in the top raw.

Figure 1

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

CEO *ex ante / ex post* OWNERSHIP SHARE $x \equiv t$
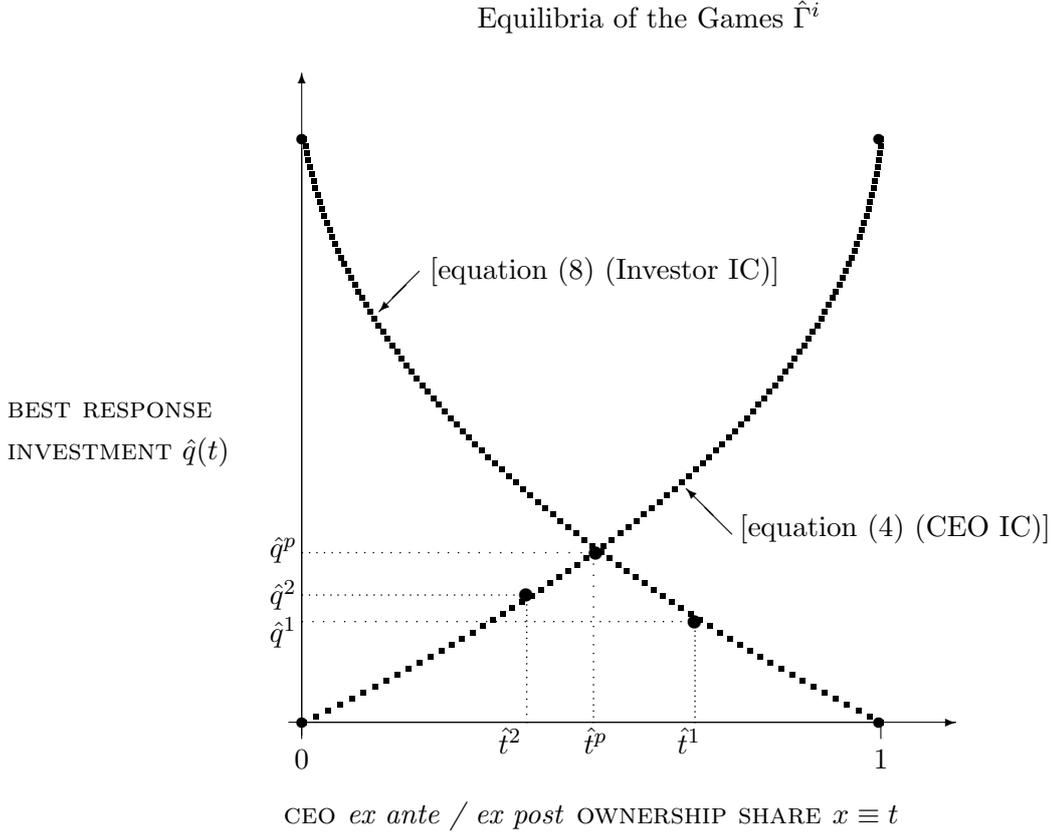
From Theorem 1 and Proposition 1: $\hat{t}^p \equiv \hat{t}^p = \check{t}$, and

$$\hat{t}^2 < \hat{t}^p < \hat{t}^1 \quad \text{and} \quad \hat{\mathbf{q}}^1 < \hat{\mathbf{q}}^2 \quad \text{if} \ \omega < \xi.$$

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

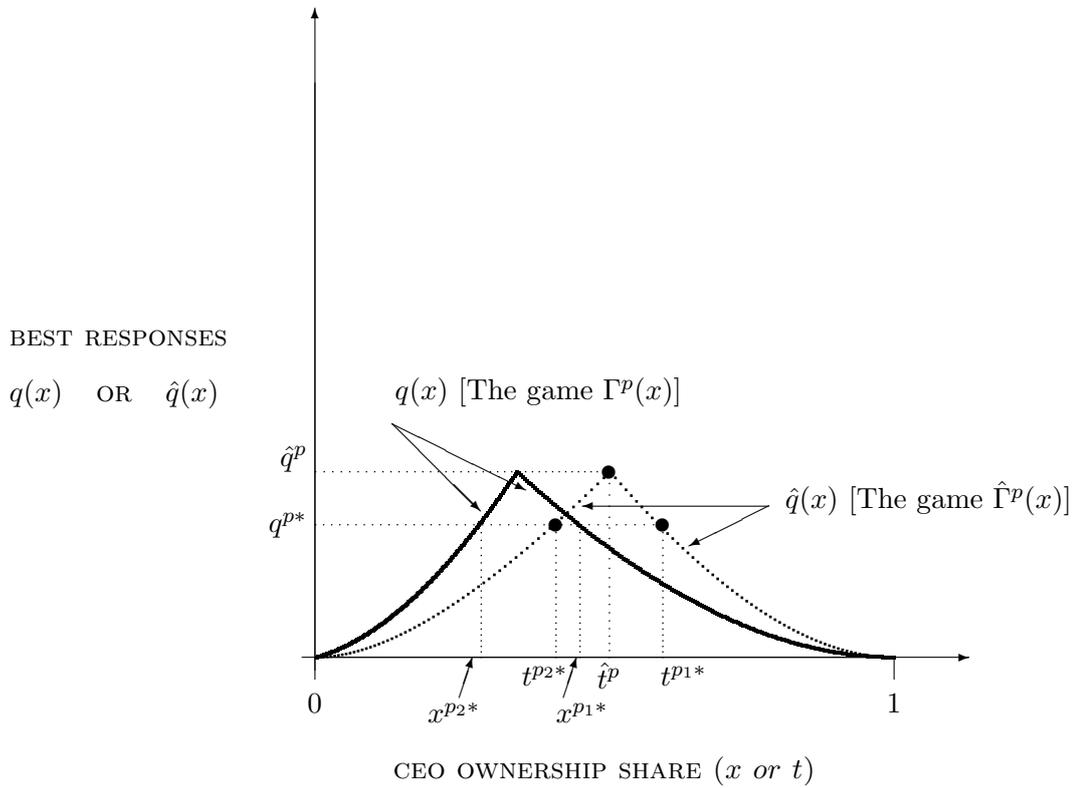$$\hat{\mathbf{q}}(t) = (\min(q_1(t), q_2(t)), \min(q_1(t), q_2(t)))$$

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

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

$$(1 - t)\Phi'(\mathbf{q}) - \xi = 0, \quad \mathbf{q} = (q_2, q_2) \tag{8}$$

Figure 2

Equilibria of the Games $\hat{\Gamma}^p$ and Γ^p

From Theorems 1 and 2:

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

From Remark 1:

$$q^{p_1*} = q^{p_2*} = q^{p*} \leq \hat{q}^p \quad \text{and} \quad t^{p_2*} \leq \hat{t}^p \leq t^{p_1*}.$$
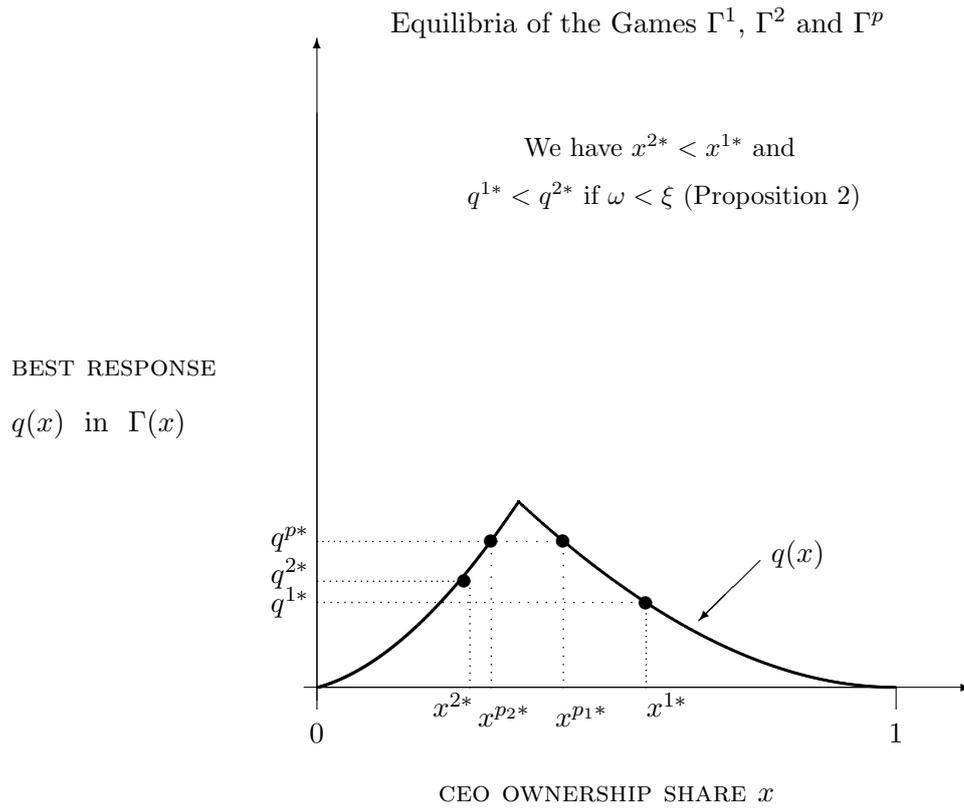
Figure 3

Equilibria of the Games Γ^1, Γ^2 and Γ^p

We have $x^{2*} < x^{1*}$ and

$q^{1*} < q^{2*}$ if $\omega < \xi$ (Proposition 2)

BEST RESPONSE

$q(x)$ in $\Gamma(x)$

CEO OWNERSHIP SHARE x

Figure 4

Equilibria of the Games Γ^1, Γ^2 and Γ^p

We have $q^{1,2*} \leq q^{p*} \leq \hat{q}^p$ and

$t^{2*} \leq t^{p_2*} \leq t^{p_1*} \leq t^{1*}$ (Theorem 2)

BEST RESPONSE

INVESTMENT

$\hat{q}^p$

q^{p*}

q^{2*}
q^{1*}

$\hat{q}(t)$

$\hat{t}^p$

0 t^{2*} t^{p_2*} t^{p_1*} t^{1*} 1

CEO OWNERSHIP SHARE t