WORKING PAPER NO. 148

Competitive Pressure, Incentives and Managerial Rewards

Marcello D'Amato, Riccardo Martina, Salvatore Piccolo

November 2005

This version July 2006

University of Naples Federico II

University of Salerno

Bocconi University, Milan

CSEF - Centre for Studies in Economics and Finance – UNIVERSITY OF SALERNO
84084 FISCIANO (SA) - ITALY
Tel. +39 089 96 3167/3168 - Fax +39 089 96 3167 – e-mail: csef@unisa.it

WORKING PAPER NO. 148

Competitive Pressure, Incentives and Managerial Rewards [*]

Marcello D'Amato[♥], Riccardo Martina[♠], Salvatore Piccolo [♦]

Abstract

The paper examines the equilibrium relationship between managerial incentives and product market competition in imperfectly competitive industries. In a simple managerial economy, where owners simultaneously choose reward schemes and managers are privately informed on firms. production technologies, it is showed that a competing-contracts effect, at play under high powered incentive schemes (contracts based on firms' profits), may induce competitive pressure to elicit managerial effort. An inverted-U shaped relationship between product market competition, managerial effort and agency costs thus obtains when contracts are based on firms' profits. Remarkably, whenever competition is strong enough, low powered incentive schemes (contracts based on production costs) may survive in equilibrium with detrimental effects on welfare.

JEL Classification: D82, L13, L22

Keywords: competing contracts, cost-target, managerial .rms, pro.t-target, product market competition, vertical hierarchies, X-inefficiency

[*] We thank P. Bertoletti, J. Kastl, A.Ma, M. Pagano, G. Pavlov, C. Poletti, L. Quesada, W. Rogerson, M. Whinston and all participants to seminars held at CSEF-IGIER Symposium on Economics and Institutions (Anacapri, 2005), EARIE (Porto, 2005), EEA Meeting (Amsterdam, 2005), Northwestern University and University of Pavia. Of course, all remaining errors are ours. A previous version of the paper has circulated as "Endogenous Managerial Contracts".

[♥] University of Salerno and CSEF

[♠] University of Naples "Federico II" and CSEF

[♦] University of Salerno, CSEF and Northwestern University.

Contents

1 Introduction

The question of whether competition is conducive to efficiency has been the focus of an intense debate among economists and policy makers over the last decades. Whereas economic theory convincingly argues that more competition has beneficial effects on allocative efficiency, much less clear cut results have been obtained in explaining why, and to what extent, competition drives firms to reduce costs and enhances productivity growth. In the case of profit-maximizing firms, a well established tradition argues for a positive relationship between market power and investment in innovation (the Shumpeterian view). As for managerial firms, instead, the impact of competition on x-efficiency is complicated by the design of managerial incentives.

As conjectured by Jensen and Meckling (1976), competitive pressure has no direct impact on the efficiency frontier of managerial firms whenever relative performance contracts are enforceable, so that internal agency constraints are *isolated* from competitive forces.[1] In real world, however, the idea that owners are able to exploit yardstick competition, and can achieve full extraction of rents, may be questioned on several grounds.[2] Admittedly, the empirical research has produced little support to the use of relative performance in managerial contracts (see Murphy, 1999, among many others).

Assuming away the possibility of enforcing relative performance, the interaction between competitive pressure, managerial incentives and contract design is much more subtle. In this regard, one of the key issues is the understanding of how the appropriation of rents by managers interacts with market competition under alternative arrangements governing the distribution of firms' surplus between shareholders and managers. This paper provides an analysis of the relationship between managerial rents, market competition and efficiency by taking a principal-agent perspective. In contrast with the bulk of the existing literature, though, in our framework managerial contracts are endogenously

[1] As pointed out by the literature on yardstick competition, owners' ability to control managerial behavior can be substantially improved within more competitive environments, provided that managers' private information displays common components. In all these circumstances market information wipes out the *informational* monopoly power that managers enjoy at the revelation stage in a principal-agent set-up (see Bertoletti and Poletti, 1997, for a clear statement of this point).

[2] On the one hand, except than in the case of firms quoted on perfect stock markets, it is not always the case that market information is readily available and verifiable by third parties enforcing contracts. On the other hand, somewhat natural features of imperfectly competitive markets may severely limit owners' benefits from yardstick competition. See Bebchuck et al. (2002) for a convincing argument in support of the view that observed managerial rents should suggest that limited enforceability of efficient contracts is a relevant issue. In the same spirit, Sappington, (2002), argues that, in regulatory practices such contracts are not often observed.

chosen by owners among different alternatives.

A key feature of the analysis is to start with the definition of a pre-specified set of contractual instruments available to owners in order to control managers' misbehavior. We consider two alternative remuneration schemes, a *cost-based*, a direct measure of managerial activity, and a *profit-based* one, a measure of market performance. This assumption captures common features of real-world contracting practices since executives' compensations are typically based on measures such as accounting profits or operation costs. Moreover, it also provides a simple environment to examine the equilibrium determinants of managerial contracts, their efficiency properties, and the effects of product market competition on managerial incentives.

Our analysis is performed in a set-up where two managerial firms, producing differentiated goods, compete on a market by setting quantities. Managers, who have private information on firms' (uncertain) production technologies, perform an unverifiable cost-reducing activity and choose quantities; while owners simultaneously choose contracts from the pre-specified set of alternative mechanisms. As we show the selection of the contractual mode affects the competitive behavior of firms at the market stage. In turn, the intensity of product market competition shapes the set of equilibrium contracts.

The effect of competition on managerial incentives depends upon the measure of managerial performance (costs, profits) available to owners. If managerial compensations are conditioned on costs, the internal agency problem is *isolated* from the impact of competitive pressure. If, instead, owners condition transfers on profits, competition has a *direct* impact on agency costs. Asymmetric information is key to these results. First, adverse selection forces owners to grant rents to their managers in order to induce separation of types. Crucially, this feature allows us to argue that market competition *directly* influences revelation constraints as well as managerial rents under profit-target. Second, because of the moral-hazard issue, the two kinds of contracts have different effects on allocative efficiency so that information rents are sensitive to the performance measure used to design incentives. This also allows us to shed light on the mechanism through which managerial performance is influenced by competitive forces.

More generally, our set-up allows us to disentangle the differences between cost-target and profit-target contracts as due to the way owners exploit the information disclosed by managers and use it to grant rents. The revelation of a low cost state, for instance, provides two bits of information: a good news concerning productive efficiency and a bad news as for the toughness of market competitors. Cost-target contracts only allow owners to exploit the former piece of information, thus leaving managers with informational monopoly power at the revelation stage. Contracts contingent on market performance, instead, provide flexibility to the owners, in that managerial rewards are reactive to changes in the underlying competitive environment. Despite profit-target contracts display better informative properties relative to cost-target ones, we show that this latter regime *can* emerge in equilibrium, especially in very competitive environments. From a normative perspective, the efficiency properties of these regimes are characterized, and it is demonstrated that cost-based contracts are detrimental both to social welfare and consumers.

As for the impact of competitive pressure on both managerial effort and agency costs, beyond a *scale effect* driving managers to reduce effort as competition becomes more fierce, we show that an opposite *pure agency effect* is at play *directly* through information rents. The key idea is that, under profit-based schemes, more fierce competition reduces these rents by *relaxing* the rent-extraction-efficiency trade-off. Each owner can thus shift up the allocation assigned to inefficient types towards its first-best level, thereby alleviating x-inefficiency. Under mild assumptions, this effect prevails over the scale effect and calls for a positive impact of product market competition on managerial effort. An inverted-U shaped relationship between effort, agency costs and market competition then obtains as a consequence of the tension between these two effects. Interestingly, such a non-linear relationship captures the evidence provided in a recent contribution by Aghion et al. (2005) studying a panel of U. K. industries during the period of liberalization reforms undertaken over the 1970s and 1980s.

The idea that competition is conducive to efficiency has been a common belief among economists and men of affair since long time. However, despite the empirical work has produced mild evidence supporting this conjecture[3], the theoretical literature has often expressed contrasting views. In a seminal article, Hart (1983) shows that competition has beneficial effects on managerial slack if managers are privately informed on a common technological shock and the measure of entrepreneurial firms in the economy is large enough.[4] Scharfstein (1988) and Hermalin (1992), prove that this result

[3]See Aghion et al. (2005), Galdón-Sánchez and Schmitz (2002) and Nickell (1996) among many others.

[4]Hart's results are derived, however, in an economy where managerial and entrepreneurial firms compete. Within this

hinges on the very large degree of managers' risk aversion and that, with a more standard preference structure, the opposite relation between incentives and competition obtains. Subsequently, Martin (1993) studied a Cournot oligopoly with information asymmetries and showed that, under ex-post cost observability, a measure of x-inefficiency increases as market concentration falls. Bertoletti and Poletti (1997), pointed out that this result does not rely on a *genuine* effect of market competition on managerial incentives. The reason being that the impact of competition on productive efficiency in Martin's model is driven by a scale effect at play only via marginal revenues.[5]

The positive impact of competition on managerial effort has been showed by a number of works based on financial market imperfections. The main idea (see Schmidt, 1997, and Stennek, 2000) is that if owners face limited liability constraints and may not be able to pay out managers in some states of the world, competition reduces managerial slack simply because managers will be willing to reduce the probability of such states. Notice that, differently from the results that we obtain in the paper, the effectiveness of this mechanism is driven only by the impact of competition on managers' participation constraints. Finally, a similar mechanism is at play in a pure moral hazard setting with free entry. Raith (2003), for instance, shows that greater product market competition, as a result of increased product substitutability, unambiguously drives principals to provide agents with stronger incentives towards cost reduction.

Our contribution adds to previous literature in three respects. First, instead of taking the contracting technology as exogenously given, we model the choice of the contractual modes as an endogenous variable controlled by firms' owners. This allows us to carefully investigate the relationship between product market competition, constrained efficiency and equilibrium managerial contracts. It turns out that when products are relatively close substitutes, owners may end up playing cost-based schemes and implement a market allocation *sub-optimal* relative to that achieved under profit-target. This result shows that, in a principal-agent set-up where owners may choose among different types of contracts, firms' equilibrium behavior may not achieve constrained efficiency. As a consequence, the effect of competition on the internal organization of firms should be carefully assessed from a public policy

setting competition makes the performances of different firms interdependent via prices, thereby reducing managerial slack.

[5] They argue that, with un-correlated managers' types, revelation constraints are isolated from competitive pressure. With common components and under ex-post market variables verifiability, they show that first-best productive efficiency is restored, see also Riordan and Sappington, (1988), and Crémer and McLean, (1988).

perspective. Second, we point out that when managerial rewards are conditioned on profits, *a pure agency effect*, may drive product market competition to have a positive impact on managerial effort. In contrast to the previous literature, mainly focused on participation constraints, this effect is at play only through revelation constraints introduced by adverse selection. Finally, having showed that endogenous contracting may lead to multiple equilibria, we have provided a rationale for why agency theory is not at odds with the observed heterogeneity of governance arrangements in managerial firms and, more fundamentally, with the survival of incentive schemes not sensitive to firm's performance (Murphy, 1999).

The remainder of the paper is organized as follows: Section 2 sets up the model. Section 3 briefly describes the complete information benchmark. Section 4 studies the model under asymmetric information and characterizes the equilibrium of the contracting stage for the case of perfect correlation among managers' types. In Section 5 we study the implication of equilibrium contracts for the impact of increased competitive pressure on x-efficiency. Section 6 extends the results of the paper to a more general class of economies. Finally, Section 7 concludes. All proves are relegated to an Appendix.

2 The Model

Players and Environment Consider an industry where two managerial firms, producing differentiated goods, compete by setting quantities. Each firm is run by a manager who is privately informed about the firm's production technology. The (inverse) demand is symmetric for both markets with $p_i(q_i, q_j) = A - q_i - bq_j$, where q_i is the quantity produced of the *i-th* product, p_i is the final price level charged for this product, $b \in [0, 1]$ is the degree of products' substitutability and A denotes an exogenous measure of consumers' willingness to pay. Firms' production technology are linear and defined by the cost function $C_i(q_i, \tilde{\theta}, e_i) = (\tilde{\theta} - e_i)q_i$, where $\tilde{\theta}$ denotes the realization of a (common) random variable distributed on a discrete support, $\Theta \equiv \{\theta_L, \theta_H\}$, with $\Pr(\tilde{\theta} = \theta_H) = \mu$. One can think of this variable as being a shock to the cost of an essential raw input used to produce both final goods.[6] The variable e_i measures an unverifiable cost-reducing activity (effort) performed by the *i*-th

[6] We shall discuss in a concluding section that the analysis extends immediately to an environment with large enough (positive) correlation. The proof is based on a continuity argument.

manager. Managerial activity is assumed to be costly and $\psi(e_i) = e_i^2/2$ denotes the effort disutility for every i-th manger. Managers are risk neutral and their preferences are represented by the utility function $u(w_i, e_i) = w_i - \psi(e_i)$, where w_i denotes a monetary transfer (wage) paid-out by the i-th risk neutral firm owner. Marginal costs of the i-th firm are defined by $c_i = \theta - e_i$, while $\tau_i = p_i(q_i, q_j) - c_i$ denotes net, average profits.

Merely for expositional simplicity we normalize $\theta_H - \theta_L = 1$; furthermore, to guarantee interior solutions of the optimization programs displayed below, we assume $A > \theta_H > \theta_L > 1 + 3(1-\mu)/\mu$. As we shall explain, this restriction captures the idea that effort by high-cost (inefficient) managers, as well as their produced output, must be worthwhile to owners. Alternatively, this condition can be expressed as $\mu > \varepsilon$ with ε being positive and chosen so as to guarantee that both efforts and outputs are positive in equilibrium. In order to make the problem interesting, in the rest of the analysis we only consider this case. Finally, as usual, sometimes we shall refer to θ as to the managers' type.

Contract Space Each firm is represented by an *exclusive,* principal-agent relationship. Owners (principals) hire managers before production occurs but after uncertainty is resolved. They have the full bargaining power and offer contracts through a take-it-or-leave-it offer. This assumption captures the idea that managerial services are supplied in a competitive fashion and that managers are selected from a very large population of agents. We invoke the Revelation Principle[7] in defining the set of incentive feasible allocations, so that each owner-manager pair plays a communication game before the competitive stage. Therefore, for any given direct, truthful, revelation mechanism chosen by the i-th owner, the i-th manager must report a message, $m_i \in \Theta$, about the state of the production technology. Two kinds of managerial contracts are studied: (i) a profit-based scheme, referred to as *profit-target*; and (ii) a cost-based one, labeled *cost-target*. The reason why we restrict owners' strategies to this alternatives relies on two simple arguments. In the first place, our contribution provides a first step in extending previous literature where either profit-target (Hart, 1983) or cost-target (Martin, 1993, Schmidt, 1997, Stennek, 2000, among others) have been studied in isolation. Secondly, accounting profits and operation costs are the two natural performance measures (Murphy, 1999) upon which CEO's compensation packages are conditioned.

[7] See Laffont and Martimort (2002, Ch. 2), and Martimort (1996) among others.

Let $\mathcal{S} \equiv \{\mathcal{C}_i^p, \mathcal{C}_i^c\}$ be the space of deterministic, truthful revelation mechanisms for this simple economy. In the following we denote by $\mathcal{C}_i^p \equiv \{\tau_i(m_i), q_i(m_i), w_i(m_i)\}_{m_i \in \Theta}$ a profit-target mechanism specifying, for each message m_i, an average profit-target[8], $\tau_i(m_i)$, an output level, $q_i(m_i)$, and a monetary transfer, $w_i(m_i)$. And by $\mathcal{C}_i^c \equiv \{c_i(m_i), q_i(m_i), w_i(m_i)\}_{m_i \in \Theta}$ a cost-target contract[9] dictating, for each message m_i, an average cost-target, $c_i(m_i)$, in addition to an output level and a monetary transfer defined as above. Of course, to rule out the possibility of renegotiation issues (see Caillaud, Jullien and Picard, 1995), owners can fully commit to any mechanism belonging to $\mathcal{S}$.

It is worthwhile stressing that the possibility of enforcing contracts contingent on both costs and profits is also ruled out. The reason for imposing such an assumption is twofold: (i) were this type of contracts allowed, owners could achieve full-extraction[10], a feature which seems to be in sharp contrast with the evidence showing that managers do enjoy positive rents (Murphy, 1999); (ii) seldom in real-life contracts display this feature, they rather appear simple and are usually contingent only upon one measure of managerial performance. Perhaps, a simple explanation for this evidence is that verifying at the same time operation costs and accounting profits can be very expensive in practice because of enforcement and monitoring costs.

Observe also that, without loss of generality, we explicitly rule out the possibility of having contracts contingent only on sales. Indeed in our setting such contracts would always be dominated by every mechanism belonging to $\mathcal{S}$ (see Martimort and Piccolo, 2006).[11]

Equilibrium Concept Following the notation introduced by Prat and Rustichini (2005), in what follows we shall analyze a *game played through agents* (GPTA), $\mathcal{G}$, where the set of players is defined by the two owner-manager pairs composing the competing hierarchies.[12] The owners' action space,

[8] Typically, this remuneration scheme can be implemented by a menu of linear contracts of the form $w = B + \alpha(\tau^R - \tau^*)$, where B is a fixed payment, α measures the incentive power of the scheme, τ^R denotes the realized profit level, whereas τ^* is the expected (announced) profit level.

[9] This type of contract follows the same logic as the pure cost of service introduced by Laffont and Tirole (1986). In real-life this mechanism is implemented by a menu of linear contracts of the form $w = B + \alpha(c^R - c^*)$, where c^R is the realized marginal costs, while c^* is the announced one.

[10] We thank Gregory Pavlov and Michael Whinston for pointing this out. It is worth noticing, however, that contracts based on both costs and profits would not yield first-best allocations under imperfect correlation of types and managers' limited liability.

[11] The idea is simple. Every allocation implemented with a contract specifying only sales, i.e., $\{q_i(\theta), w_i(\theta)\}_{\theta \in \Theta}$, can always be replicated by a more complete mechanism dictating also a cost or a profit target beyond sales and transfers.

[12] It is worth noticing, however, that while in Prat and Rustichini (2005) principals only set transfers, in our analysis they choose among different mechanisms due to adverse selection.

$\mathcal{S}$, is the set of available mechanisms defined above; while the managers' action space, $\mathcal{M} \equiv \Theta \times \{a, r\}$, entails a message on the realization of the production technology, $m_i \in \Theta$, and the decision of accepting, a, or refusing, r, the contract offer. The extensive form game is as follows. First, principals choose their mechanisms simultaneously and non-cooperatively. Second, agents deliver messages and accept or refuse contracts. Finally, without observing contract in the rival hierarchy, managers exert effort and announce quantities. Throughout we shall assume that contracts between principals and agents are unobservable to other players in the game. Such an assumption rules out issues on the commitment value of managerial contracts which are not addressed in the paper.[13] Assuming that managerial contracts are public information seems in fact to be often inappropriate. As argued by Katz (1991), the contract between an executive and his firm may largely be an implicit, self enforcing one. Although often legislations do require firms to announce the amount of compensation paid to their top managers, observing the rule by which these compensation are calculated may be a very difficult task. In addition, in the example at hand renegotiation issues also shed doubts on how effective is the commitment value of contracts' observability.[14]

We restrict attention to pure-strategy (Nash) equilibria.[15] For any given realization of firms' production technology, a pure strategy for the i-th manager of type θ, is a decision rule mapping Θ into $\mathcal{M}$, i.e., $\phi : \Theta \to \mathcal{M}$; while a pure strategy for the i-th owner is just an element of the contract space $\mathcal{S}$. Let $\pi_i^{t,t'} = \sum_{\theta \in \Theta} \Pr(\theta)\pi(q_i^t(\theta), e_i^t(\theta), w_i^t(\theta), q_j^{t'}(\theta), \theta)$, with $t, t' \in \{c, p\}$, be the expected profit of the i-th owner from choosing the mechanism $\mathcal{C}_i^t$ when managers reveal truthfully their types and the j-th owner chooses the mechanism $\mathcal{C}_j^{t'}$, with $\pi(.) = (p_i(q_i(\theta), q_j(\theta)) - (\theta - e_i(\theta)))q_i(\theta) - w_i(\theta)$. Moreover $u_i(w_i^t(m_i), e_i^t(m_i), m_j, \theta)$ denotes the type θ utility of the i-th manager delivering a message m_i at the revelation stage, when the mechanism $\mathcal{C}_i^t$ is implemented. Notice that under profit-target this function may well depend on the j-th manager's message. Moreover, let $\Omega_i^{t',t}$ denote the set of incentive

[13] These issues are typically addressed by setting up a two-stage game where, in the first place, owners commit to a contractual scheme and then, in the second stage, managers compete either in quantities or prices after having observed the contracts enforced within competing hierarchies, see Fershtman and Judd (1987) and Sklivas (1987) among many others.

[14] In this respect, Katz (1991) argues that *"it may be well too costly to write and enforce a contract among the agent and other players in the game, that says there is no other contract between the agent and his principal; monitoring all possible payments made between the agent and his principal in response to the agent's behavior in one transaction may be impossible..."* .

[15] Indeed, in order to take into account mixed strategies one should consider owners mixing among different types of mechanisms (see for instance Bontems and Bourgeon, 2000). However, this scenario will not be studied for the same reason why relative performance have been ruled out of our analysis.

feasible allocations for the i-th manager under the t'-th contract whenever the j-th owner offers the t-th contract to her manger. A *(pure-strategy) truthful information revelation Nash equilibrium* of $\mathcal{G}$ is a symmetric Nash equilibrium in which players use pure-strategies, managers reveal truthfully their type and accept the contracts offered by owners. It is worthwhile observing that, in the following, we will consider Nash equilibria implementation, meaning that each manager must have an incentive to truthfully reveal his type, provided that his competitor does the same (Myerson, 1982, and Martimort, 1996, among others). The definition below states formally the equilibrium concept used to solve the game.

Definition 1 *For every $\theta \in \Theta$, a (pure-strategy) truthful information revelation Nash equilibrium of the game $\mathcal{G}$ is a pair of contracts $(\mathcal{C}_j^{t'}, \mathcal{C}_i^t) \in \mathcal{S}^2$ and a pair of messages and acceptance rules $(\sigma_i, \sigma_j) \in \Theta^2 \times \{a, r\}^2$, with $\mathcal{C}_i^t \equiv \{q_i^t(\theta), e_i^t(\theta), w_i^t(\theta)\}_{\theta\in\Theta}$, $\mathcal{C}_j^{t'} \equiv \left\{q_j^{t'}(\theta), e_j^{t'}(\theta), w_j^{t'}(\theta)\right\}_{\theta\in\Theta}$ and $\sigma_i = \sigma_j = (\theta, a)$, such that:*

(I) *Each manager reveals truthfully his type and accepts the contract given that his competitor does so. Therefore, $\{q_i^t(\theta), e_i^t(\theta), w_i^t(\theta)\}_{\theta\in\Theta} \in \Omega_i^{t,t'}$ and $\left\{q_j^{t'}(\theta), e_j^{t'}(\theta), w_j^{t'}(\theta)\right\}_{\theta\in\Theta} \in \Omega_j^{t',t}$.*

(II) *The allocations $\{q_i^t(\theta), e_i^t(\theta), w_i^t(\theta)\}_{\theta\in\Theta}$ and $\left\{q_j^{t'}(\theta), e_j^{t'}(\theta), w_j^{t'}(\theta)\right\}_{\theta\in\Theta}$ respectively solve:*

$$\max_{\langle q_i(.), e_i(.), w_i(.)\rangle_{\theta\in\Theta} \in \Omega_i^{t,t'}} \sum_{\theta\in\Theta} \Pr(\theta)\pi(q_i(\theta), e_i(\theta), w_i(\theta), q_j^{t'}(\theta), \theta)$$

and,

$$\max_{\langle q_j(.), e_j(.), w_j(.)\rangle_{\theta\in\Theta} \in \Omega_j^{t',t}} \sum_{\theta\in\Theta} \Pr(\theta)\pi(q_j(\theta), e_j(\theta), w_j(\theta), q_i^{t}(\theta), \theta)$$

(III) *The following inequalities must hold for each i-th owner:*

$$\pi_i^{t,t'} \geq \max_{\langle q_i(.), e_i(.), w_i(.)\rangle_{\theta\in\Theta} \in \Omega_i^{t',t'}} \sum_{\theta\in\Theta} \Pr(\theta)\pi(q_i(\theta), e_i(\theta), w_i(\theta), q_j^{t'}(\theta), \theta).$$

and,

$$\pi_j^{t',t} \geq \max_{\langle q_j(.), e_j(.), w_j(.)\rangle_{\theta\in\Theta} \in \Omega_i^{t,t}} \sum_{\theta\in\Theta} \Pr(\theta)\pi(q_j(\theta), e_j(\theta), w_j(\theta), q_i^{t}(\theta), \theta).$$

Timing The overall sequence of events is as follows:

- T=1, Uncertainty about costs is realized and only managers observe it.

- T=2, Owners *simultaneously* offer contracts to their managers. If an offer is rejected, both the parties composing a vertical hierarchy enjoy their outside option normalized to zero.

- T=3, If contracts are accepted, the communication game takes place. Managers deliver messages, exert effort and simultaneously announce the quantities specified in their contracts without observing the contract implemented within the competing organization.

- T=4, Payments are made according to the realization of contracted variables.

3 The Complete Information Benchmark

This section analyzes the model under complete information. In this setting, one can show that owners implement the complete information allocation simply by selling out firms to managers. Let $u_i(\theta) = (p_i(q_i(\theta), q_j(\theta)) - (\theta - e_i))q_i(\theta) - \psi(e_i) - F_i(\theta)$ define the type-contingent utility of the i-th manager, where $F_i(\theta)$ is a fixed, type-contingent monetary fee from manager-i to owner-i, and let,

$$\mathcal{B}_{\theta,i} \equiv \left\{ (F_i(\theta), q_i(\theta)) \in \Re^2_+ : \max_{e_i \in [0,\theta]} \{(p_i(q_i(\theta), q_j(\theta)) - (\theta - e_i))q_i(\theta) - \psi(e_i) - F_i(\theta)\} \geq 0 \right\},$$

be the set allocations such that each i-th manager of type θ is willing to accept the contract. The i-th owner must then design a contract, $\{q_i(\theta), F_i(\theta)\}_{\theta \in \Theta}$, so to maximize $F_i(\theta)$ subject to $(F_i(\theta), q_i(\theta)) \in \mathcal{B}_{\theta,i}$ and $q_i(\theta) \geq 0$ for all θ. As standard, in an interior solution first-order necessary conditions equate marginal revenues to marginal costs, i.e., $A - 2q_i(\theta) - bq_j(\theta) = \theta - e_i(\theta)$, and $q_i(\theta) = e_i(\theta)$ for all θ. At a symmetric Nash equilibrium of the market game one has:

$$q^*(\theta) = e^*(\theta) = \frac{A - \theta}{1 + b}. \tag{1}$$

In order to guarantee interior solutions in the following we assume $A \in (\theta_H, 2\theta_L)$, with $\theta_H < 2\theta_L$ since $\theta_L > 1$. Next lemma shows that the above allocation is achieved either under cost-target or under profit-target contracts. As a result, under complete information these mechanisms are outcome and pay-off equivalent.[16]

Lemma 1 *Under complete information, any equilibrium of $\mathcal{G}$ entails the allocation* $\{e^*(\theta), q^*(\theta)\}_{\theta\in\Theta}$.

This result has two simple corollaries. First, both contractual regimes are a Nash equilibrium of $\mathcal{G}$; second, they yield the same consumers' surplus, as well as the same level of (total) social welfare. At more abstract level, this result is similar to Katz (1991) showing that the use of agents in games does not have effects on the equilibrium outcome if there exists a contract which perfectly internalizes the externality between principals and agents. We shall see that this result drastically changes under asymmetric information and unenforceability of relative performance.

Finally, as for the equilibrium marginal cost, $c^*(\theta) = \theta - q^*(\theta)$, one can easily show that it increases with respect to b in all states. Even if the effort is set at its first-best level — there is no x-inefficiency — increasing product market competition weakens the incentive to reduce costs. To be more precise, when b increases the marginal revenue of each firm decreases, thus determining a reduction of output. Since production technologies display "complementarity" between effort and output, more competition will also call for a reduction of effort, which in turn raises marginal costs; a scale effect (see Varian, 1994, and Vives, 2005, among many others).

4 Asymmetric Information

This section introduces asymmetric information. Two main sources of inefficiency are at play under the two contractual regimes. First, information asymmetries force owners to give up information rents to managers in order to induce separation of types, a *distributive effect*. Second, a *rent-extraction effect* leads the market allocation to be distorted away from its first-best level. Of course, the magnitude of these rents will be crucially affected by the type of mechanism enforced within each competing hierarchy. These effects originate from the possibility of dishonest behavior by managers at the revelation stage, and the profitability of such mimicking behaviors is sensitive to the features of the observable, costs or profits, used by a firm owner to foster types' separation. More specifically, under cost-target contracts, the possibility of claiming that a high-cost realization is induced by an

[16] The proof of this result is standard, thus it is omitted.

unfavorable realization of θ, whereas it is only due to low effort, makes efficient managers willing to mimic inefficient ones at the revelation stage. An analogous force shapes incentives under profit-target; though, under this regime, a competing-contracts effect is also at play.[17] As we show, while under a cost-target regime managers enjoy an *informational* monopoly position at the revelation stage, conditioning managerial rewards on profits, allows owners to weaken this position and, in turn, to shape more efficiently agency costs. In fact, the adoption of a profit-target contract *relaxes* the revelation constraint of efficient managers, whereas it *tightens* that of inefficient ones relative to cost-target.

The section characterizes the pure strategies Nash equilibria of $\mathcal{G}$. After having studied the cases where owners play symmetrically, it is shown that, for a given range of parameters, both contractual regimes can emerge as a Nash equilibrium of $\mathcal{G}$. We shall argue that the competing-contracts effect is key to this result.

Incentive Feasible Allocations under Cost-Target To begin with, let us consider the maximization problem that the i-th owner solves under a cost-target contract. As discussed above, an incentive feasible allocation must satisfy two requirements: (i) it must induce managers to accept the contract; and (ii) it must also foster separation of types. Denote $u_i(\theta) = w_i(\theta) - \psi(e_i(\theta))$ the type-dependent utility of th i-th manger, and let $\tau_i(\theta) = A - q_i(\theta) - bq_j(\theta) - c_i(\theta)$ and $e_i(\theta) = \theta - c_i(\theta)$ for all θ. Formally, the owner-i's optimization problem, $\mathcal{P}_i^c$, is to design a contract, $\{c_i(\theta), q_i(\theta), w_i(\theta)\}_{\theta\in\Theta}$, so to maximize the expected profits, $\sum_{\theta\in\Theta} \Pr(\theta)\{\tau_i(\theta)q_i(\theta) - \psi(e_i(\theta)) - u_i(\theta)\}$, subject to incentive compatibility (IC) and participation constraints (PC):

$$(\text{PC}_L) \quad u_i(\theta_L) \geq 0, \ (\text{PC}_H) \quad u_i(\theta_H) \geq 0, \tag{2}$$

$$(\text{IC}_L) \quad u_i(\theta_L) \geq u_i(\theta_H) + \psi(e_i(\theta_H)) - \psi(e_i(\theta_H) - 1), \tag{3}$$

$$(\text{IC}_H) \quad u_i(\theta_H) \geq u_i(\theta_L) + \psi(e_i(\theta_L)) - \psi(e_i(\theta_L) + 1), \tag{4}$$

moreover, the following non-negativity constraints must hold too:

$$q_i(\theta) \geq 0, \ 0 \leq c_i(\theta) \leq \theta, \ \text{for every } \theta \in \Theta.$$

[17] See Martimort (1996) for a characterization of this effect in a general set-up also encompassing the case of strategic complementarity between firms' actions.

Notice that, under this contractual mode, product market competition does not play any direct role on the set of revelation constraints needed for types' separation. The agency issue within each vertical organization is *isolated* from the effects of market competition, and managers get monopoly power at the revelation stage.

Incentive Feasible Allocations under Profit-Target We now turn to present the problem under a profit-target regime. As above, an incentive feasible allocation must satisfy incentive compatibility and participation constraints for all managers' types. Let $e_i(\theta) = \tau_i(\theta) + q_i(\theta) + bq_j(\theta) + \theta - A$, the owner-$i$'s optimization problem, $\mathcal{P}_i^p$, is to design a contract, $\{\tau_i(\theta), q_i(\theta), w_i(\theta)\}_{\theta\in\Theta}$, so to maximize the expected profits, $\sum_{\theta\in\Theta} \Pr(\theta) \{\tau_i(\theta)q_i(\theta) - \psi(e_i(\theta)) - u_i(\theta)\}$, subject to incentive compatibility and participation constraints:

$$(\mathrm{PC}_H) \quad u_i(\theta_H) \geq 0, \;\; (\mathrm{PC}_L) \quad u_i(\theta_L) \geq 0, \tag{5}$$

$$(\mathrm{IC}_L) \quad u_i(\theta_L) \geq u_i(\theta_H) + \psi(e_i(\theta_H)) - \psi(e_i(\theta_H) - 1 + \varkappa(\mathbf{q}_j)), \tag{6}$$

$$(\mathrm{IC}_H) \quad u_i(\theta_H) \geq u_i(\theta_L) + \psi(e_i(\theta_L)) - \psi(e_i(\theta_L) + 1 - \varkappa(\mathbf{q}_j)), \tag{7}$$

where $\varkappa(\mathbf{q}_j) = b(q_j(\theta_L) - q_j(\theta_H))$ and $\mathbf{q}_j = (q_j(\theta))_{\theta\in\Theta}$. Once again, the non-negativity constraints below must be satisfied too:

$$\tau_i(\theta) \geq 0, \;\; q_i(\theta) \geq 0, \;\; 0 \leq e_i(\theta) \leq \theta, \quad \text{for every } \theta \in \Theta.$$

As one can easily observe, the above revelation constraints markedly differ from the ones displayed in program $\mathcal{P}_i^c$. Only when both firms are monopolistic in their own markets, $b = 0$, the revelation constraints are the same under both regimes. The term $\pm\varkappa(\mathbf{q}_j)$ formally captures the competing-contracts effect, now at play through IC_L and IC_H. Crucially, because of types' perfect correlation, the profitability of a deviation by the i-th manager at the revelation stage is affected by the mechanism enforced within the competing hierarchy. In words, managers loose some of the informational monopoly power they have under cost-target contracts, but not completely as it would happen under pure relative performance evaluation.

More formally, if the i-th efficient manager, θ_L, mimics an inefficient one, $m_i = \theta_H$, he must exert an effort $\tilde{e}_i(\theta_H) = e_i(\theta_H) - 1 + \varkappa(\mathbf{q}_j)$ in order to perform the target $\tau_i(\theta_H)$ devised for inefficient types. Of course, this kind of deviation is profitable and provides information rents whenever the competing structure is very aggressive at the market stage, i.e., $\varkappa(\mathbf{q}_j) \leq 1$. When the competing firm is less aggressive, $\varkappa(\mathbf{q}_j) > 1$, however, the competing-contracts effect *kills* these rents. As one can infer from IC_H, in this case, inefficient types have an incentive to mimic efficient ones and countervailing incentives obtain (Maggi and Rodriguez, 1995, and Jullien, 2000, among many others). Depending upon the sign of $\varkappa(\mathbf{q}_j) - 1$, program $\mathcal{P}_i^p$ may then display different configurations of binding constraints. Therefore, cases where inefficient types enjoy positive rents and the allocation assigned to efficient ones is downward distorted (PC_L and IC_H bind) cannot be ruled out independently of contracts chosen by owners. As we will show, when both owners implement profit-target contracts, one gets $\varkappa(\mathbf{q}_j) < 1$, so that PC_H and IC_L bind. Nash equilibrium entails standard downward distortion. Efficient managers enjoy positive rents, while the allocation assigned to inefficient ones is distorted downward relative to its first-best level. At the contracting stage, though, unilateral deviations from cost-target *may* entail $\varkappa(\mathbf{q}_j) \geq 1$ under certain conditions.

4.1 Equilibrium Characterization

This section characterizes the set of Nash equilibria of $\mathcal{G}$. We prove that, beyond having a non-standard impact on the equilibrium allocation implemented under profit-target, product market competition also plays an *important* role in shaping the set of the equilibrium contracts. The symmetric Nash equilibria of $\mathcal{G}$ are characterized in two steps. First, we derive the set of payoffs and allocations obtained when owners play symmetrically, namely either of them play cost-target (profit-target). Next, a revealed preferences argument (formally developed in the appendix) allows us to derive the equilibrium contractual modes satisfying Definition 1.

Equilibrium Market Allocations under a Cost-Target Regime Assume that both owners implement cost-target contracts, by applying a standard technique, we first consider a relaxed optimization program (see Appendix) where only IC_L and PC_H bind, then we show that all remaining constraints of $\mathcal{P}_i^c$ are indeed satisfied at the solution of this program. Assuming interior solutions, one can show that the first-order necessary conditions are:

$$A - 2q_i^c(\theta_L) - bq_j(\theta_L) - (\theta_L - e_i^c(\theta_L)) = 0, \tag{8}$$

$$q_i^c(\theta_L) - e_i^c(\theta_L) = 0, \tag{9}$$

$$A - 2q_i^c(\theta_H) - bq_j(\theta_H) - (\theta_H - e_i^c(\theta_H)) = 0, \tag{10}$$

$$\mu(q_i^c(\theta_H) - e_i^c(\theta_H)) - (1-\mu) = 0. \tag{11}$$

Equations (8), (9) and (10) are standard optimality conditions requiring that, in the optimum, marginal revenues must be equated to marginal costs, exactly as under complete information. The first-order condition with respect to $c_i(\theta_H)$, equation (11), however, provides the main difference with the system of equations yielding the complete-information allocation. The reason for this relies on a standard rent extraction argument. In order to minimize the rents granted to efficient managers, owners must distort downward the effort exerted by inefficient managers relative to its first-best level. Observe also that, in this case, the dichotomy result holds (see Laffont and Tirole, 1988, Ch. 3). Specifically, while output is chosen according to the first best rule, effort (cost) needs to be distorted for rent extraction reasons. In a Nash symmetric equilibrium of the market game where both owners play cost target contract, equations (8)-(11) yield:

$$e^c(\theta_L) = e^*(\theta_L), \quad e^c(\theta_H) = e^*(\theta_H) - \frac{1-\mu}{\mu} \times \frac{2+b}{1+b}, \tag{12}$$

and,

$$q^c(\theta_L) = q^*(\theta_L), \;\; q^c(\theta_H) = q^*(\theta_H) - \frac{1-\mu}{\mu} \times \frac{1}{1+b}. \tag{13}$$

Of course, when $\mu \to 1$ the optimal contract entails first-best in both states of nature as only high-cost managers are present on the market, so that there is no need for distorting allocations. When $\mu \to 0$, instead, the distortion imposed by asymmetric information on high-cost types increases because the rent-extraction-efficiency trade-off exacerbates due to the excessive presence of low-cost types.

Next lemma shows that program $\mathcal{P}_i^c$ is well behaved at $\{q^c(\theta), e^c(\theta), w^c(\theta)\}_{\theta\in\Theta}$ and that such allocation displays standard properties of adverse selection models. Let $\mathcal{I} \equiv (\theta_H + 3(1-\mu)/\mu, 2\theta_L)$,

Lemma 2 *The allocation $\{q^c(\theta), e^c(\theta), w^c(\theta)\}_{\theta\in\Theta}$ satisfies the following properties: (i) first-order conditions (8)-(11) are necessary and sufficient for a unique optimum; (ii) both IC_H and PC_L hold as inequalities; (iii) program $\mathcal{P}_i^c$ displays interior solutions for $A \in \mathcal{I}$; (iv) no distortion at the top and downward distortion of the inefficient type's allocation.*

Since we have assumed $\theta_L > 1 + 3(1-\mu)/\mu$, one can immediately show that $\mathcal{I}$ is not empty, so that interior solutions obtain.

Equilibrium Market Allocations under a Profit-Target Regime Assume, now, that both owners implement profit-target contracts. As above, we first consider an auxiliary program (see Appendix) where only IC_L and PC_H bind in $\mathcal{P}_i^p$, then we show that at equilibrium, all remaining constraints hold as inequalities. Assuming interior solutions, one easily shows that the first-order necessary conditions are:

$$\tau_i^p(\theta_L) - e_i^p(\theta_L) = 0, \tag{14}$$

$$q_i^p(\theta_L) - e_i^p(\theta_L) = 0, \tag{15}$$

$$\mu(\tau_i^p(\theta_H) - e_i^p(\theta_H)) - (1-\mu)(1 - \varkappa(\mathbf{q}_j)) = 0, \tag{16}$$

$$\mu(q_i^p(\theta_H) - e_i^p(\theta_H)) - (1-\mu)(1 - \varkappa(\mathbf{q}_j)) = 0. \tag{17}$$

Once again, from equations (14) and (15) one can see that, at the optimum, marginal revenues must be equated to marginal costs and that efficient types produce at the complete-information level. From (16) and (17), however, one can see that inefficient types must produce below the first-best. Since $\tau^p(\theta) = q^p(\theta)$ for all θ, also in this case the dichotomy result holds. Solving for a Nash symmetric equilibrium where both owners play profit target contracts, equations (14)-(17) yield:

$$e^p(\theta_L) = e^*(\theta_L), \quad e^p(\theta_H) = e^*(\theta_H) - \frac{1-\mu}{\mu+b} \times \frac{2+b}{1+b}, \tag{18}$$

and,

$$q^p(\theta_L) = q^*(\theta_L), \quad q^p(\theta_H) = q^*(\theta_H) - \frac{1-\mu}{\mu+b} \times \frac{1}{1+b}. \tag{19}$$

Again, when $\mu \to 1$ the optimal contract entails first-best in both states of nature. Whereas when $\mu \to 0$, the distortion imposed by asymmetric information on high-cost types increases. However, as we explain in Section 5, because of the competing-contracts effect the distortion may well decrease with the degree of products' differentiation.

Next lemma finally shows that program $\mathcal{P}_i^p$ is well behaved at $\{q^p(\theta), \tau^p(\theta), w^p(\theta)\}_{\theta\in\Theta}$ and that this allocation also exhibits the standard properties of no distortion at the top, both in effort and quantities, and no rents at the bottom.

Lemma 3 *The allocation $\{q^p(\theta), \tau^p(\theta), w^p(\theta)\}_{\theta\in\Theta}$ satisfies the following properties: (i) first-order conditions (14)-(17) are necessary and sufficient for a unique optimum; (ii) both IC_H and PC_L hold as inequalities, i.e., $1 > \varkappa(\mathbf{q}_j^p)$; (iii) program $\mathcal{P}_i^p$ displays interior solutions for $A \in \mathcal{I}$; (iv) no distortion at the top and downward distortion of the inefficient type's allocation.*

Once again, as $\theta_L > 1 + 3(1-\mu)/\mu$, one can immediately show that $\mathcal{I}$ is not empty, thus interior solutions obtain.

Equilibrium We now characterize of the set of Nash equilibria of $\mathcal{G}$. To this aim, as a preliminary result we state and prove the next lemma which provides a useful description of how efforts and outputs are ordered under both (symmetric) contractual regimes,

Lemma 4 *Assume $\mu \in (0,1]$, the allocations $\{q^p(\theta), e^p(\theta)\}_{\theta\in\Theta}$ and $\{q^c(\theta), e^c(\theta)\}_{\theta\in\Theta}$ satisfy: (i) $q^p(\theta_L) = q^c(\theta_L)$ and $e^p(\theta_L) = e^c(\theta_L)$ for all b; (ii) $q^p(\theta_H) \geq q^c(\theta_H)$ and $e^p(\theta_H) \geq e^c(\theta_H)$ for all b, with equality holding only at $b = 0$.*

As we have discussed above, because of the competing-contracts effect, the incentive for efficient managers to mimic inefficient ones weakens under a profit-target regime relative to a cost-target one. To see it formally, let $\varphi(e) = \psi(e) - \psi(e-1)$ and $\vartheta(e) = \psi(e) - \psi(e-1+\varkappa(\mathbf{q}_j))$ denote the information rents granted by a firm owner to efficient managers under cost-target and profit-target, respectively. Figure 1 shows that at the effort level implemented under cost-target, $e^c(\theta_H)$, a profit-target contract allows a firm owner to reduce information rents paid-out to efficient types, $\varphi(e^c(\theta_H)) > \vartheta(e^c(\theta_H))$, provided that her competitor implements the allocation $\{q^p(\theta), \tau^p(\theta)\}_{\theta\in\Theta}$. It is thus profitable to shift upward $e^p(\theta_H)$ towards the complete-information level, so to have $e^*(\theta_H) > e^p(\theta_H) \geq e^c(\theta_H)$. Intuitively, the difference between cost-target and profit-target contracts hinges on the way they allow owners to exploit the information disclosed by managers. The revelation of a good state provides two bits of information to a firm owner: a good news concerning productive efficiency, and a bad news as for the toughness of market competitors. Cost target contracts only allow owners to exploit the former piece of information since, under this contractual mode, competition at the market stage cannot be fed in the reward structure, leaving managers with informational monopoly power at the revelation stage. Profit target, instead, provides the owner with flexibility in adjusting managerial rewards to the underlying competitive environment, thus exerting downward pressures on managerial slack and alleviating x-inefficiency. Interestingly, this result fits the evidence showing that contracts based on plants' performances entail efficiency gains relative to pure cost-reimbursement schemes.[18]

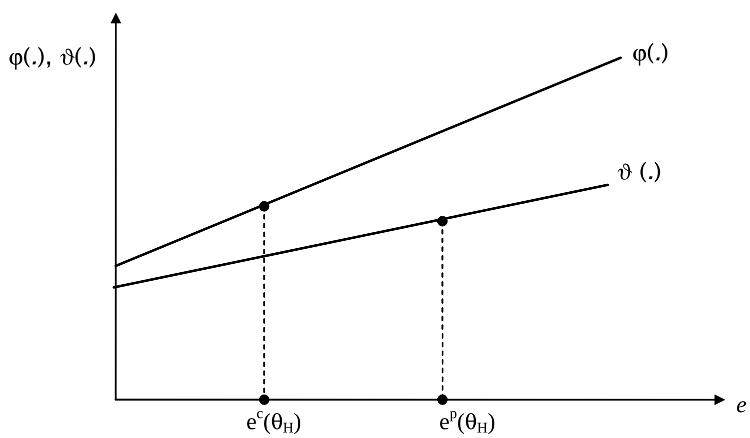

Figure 1: Information Rents under both Contracts.

Next proposition studies how these features affect profits and the characterization of the equilibrium contractual choices. To keep things tractable we focus on symmetric equilibria of $\mathcal{G}$. The possibility of asymmetric equilibria, and their implications on the qualitative results of the paper, are discussed in a concluding section. Of course, when $\mu \to \{0, 1\}$ it is likely that both types of contracts emerge in a symmetric equilibrium of $\mathcal{G}$, since in these case one gets shut down or first-best under both

[18] See Knittel (2002) and Cuñat and Guadalupe (2004) among many others.

regimes. The same holds for $b \to 0$ since when produced goods are not differentiated at all firms are monopolists on their own market. To make things interesting, in what follows we will thus consider only cases where $\mu \in (0,1)$ and $b > 0$.

To begin with, it will be convenient to define:

$$\Xi \equiv \left\{ (\mu, b) \in (0,1) \times (0,1] : 0 < \mu < 1/2,\, b_\mu^* \leq b \leq 1 \right\},$$

with $b_\mu^* = \mu/(1-\mu)$, and denote by Ξ^c its complement,

Proposition 1 *$\mathcal{G}$ displays the following properties: (i) it has a unique symmetric equilibrium where both owners play a profit-target contract whenever $(\mu, b) \in \Xi^c$; (ii) it has two symmetric equilibria where both types of contracts are played whenever $(\mu, b) \in \Xi$.*

The proposition shows that profit-target contracts are always an equilibrium of the game whereas cost-target contracts may be only if product market competition is fierce enough, $b \geq b_\mu^*$, and inefficient managers are relatively less likely than efficient ones, $\mu \leq 0.5$.

The intuition for the result is easily provided and deserves a discussion. Consider profit target as a candidate symmetric equilibrium strategy profile. An incentive feasible deviation to cost target would force a firm owner to induce her inefficient manager to behave less aggressively at the market stage, by implementing a lower effort relative to that implemented under profit-target, at the cost of increasing information rents granted to the efficient manager. This course of action is, obviously, always unprofitable since it entails both a weaker market position and larger agency costs relative to profit target.

The rationale for why cost-target contracts may survive under certain parameter configuration as an equilibrium of $\mathcal{G}$ can be easily described too. Assume a cost target contract as a candidate symmetric Nash equilibrium strategy profile of $\mathcal{G}$. Consider now an incentive feasible deviation to a profit target contract. Remember that incentive compatibility under profit target may entail countervailing incentives depending on the size of $\varkappa(.)$ in program $\mathcal{P}_i^p$, evaluated at the allocation played by the competitor in the candidate equilibrium, $\mathbf{q}^c$. Whenever $(\mu, b) \in \Xi$, i.e., if competition is sufficiently fierce and the likelihood of high cost states is sufficiently large, one can easily check that an incentive feasible deviation indeed entails countervailing incentives. In this case, however, deviation to a profit target contract is never worthwhile. The reason is that, in the deviation, incentive compatibility requires increasing the quantity-effort pair played by the manager in the bad state (high-cost) and decreasing them in the good state (low-cost) for rent extraction reasons. But, deviating to a weaker competitive stance in the good state and to a tougher one in the bad one would not be profitable whenever the bad state is unlikely and competition is strong enough. Figure 2 below graphs the equilibrium contract in the square $[0,1]^2$.

The white area in figure 2 below, Ξ^c, denotes the region where $\mathcal{G}$ displays a unique Nash equilibrium entailing profit target, while the shadowed area, Ξ, denotes that where both contractual regimes may emerge at equilibrium.

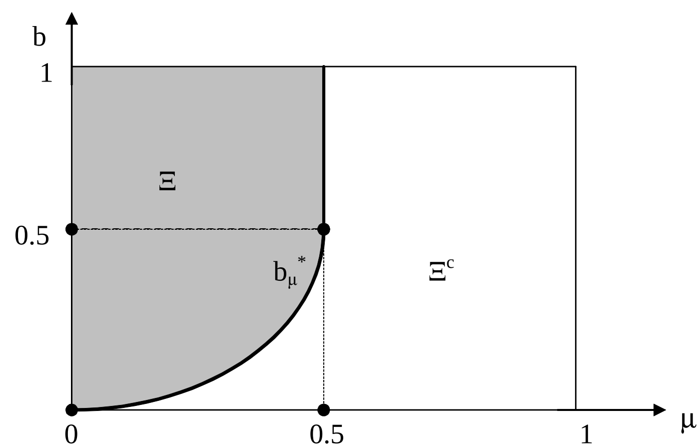

Figure 2: Equilibrium Contracts in the Square $[0,1]^2$.

Proposition 1 establishes that competition plays a crucial role in determining the features of the equilibrium contracts in economies where inefficient managers are relatively less likely than efficient ones. Remarkably, a *negative relationship* between product market competition and the efficiency properties of firms' competitive strategies obtains in this case. When products are relatively close substitutes, owners may end up playing cost-based contracts and implement a market allocation *less competitive* than that achieved under profit-target. This is the most important result of our model and, interestingly, it provides to some extent a theoretical explanation for the evidence that different executive compensation structures are used in different countries. For instance, Murphy (1999) reports that US executives receive a larger fraction of their compensation in the form of stock options than any of their global counterparts and that stock options are completely absent in 9 out of the 23 countries surveyed in the *Worldwide Total Remuneration Report*.

>From a policy perspective, it is finally worth noticing that the effects on total welfare and consumers' surplus of the two types of contracts analyzed above are quite different. Next corollary summarizes the result.

Corollary 1 *For all pairs* $(\mu, b) \in (0,1) \times (0,1]$ *cost-target contracts are detrimental to total welfare and consumers' surplus relative to profit-target. Of course, for* $b = 0$ *and* $\mu = 1$ *they are welfare equivalent.*

This result opens a number of policy issues related to the welfare effects of equilibrium organizational modes. In particular, an immediate normative implication of our analysis is that an antitrust authority concerned with the efficiency properties of different forms of vertical control in managerial firms, should carefully assess the welfare properties of reward schemes based on costs. [19]

5 X-Inefficiency

Our model has two major implications on the relationship between x-inefficiency and competitive pressure. First, as showed in Lemma 4, the equilibrium effort level implemented under a profit-target regime is larger than that obtained under cost-target contracts, which, however, may well be an equilibrium of the game. Furthermore, under profit-target a new channel through which increasing product market competition influences managerial effort emerges.

Of course, when incentives are provided via costs there exists a negative relationship between competition and x-efficiency due to a standard scale effect at play through marginal revenues, that is $\partial e^c(\theta)/\partial b < 0$ for all θ. In fact, as the revelation constraints imposed by asymmetric information on the efficiency frontier of each organization are not (directly) affected by b, and profits display complementarities between output and effort, more fierce product market competition affects negatively the equilibrium effort level only via marginal revenues. The same holds under a profit-target regime, but only for efficient managers producing at the complete-information level. As for inefficient types,

[19] Similarly, after periods of liberalization reforms aimed at relaxing competition, policy makers should regard as sub-optimal any attempt to coordinate on cost-based contractual regimes.

instead, product market competition may well have a positive impact on effort via a *pure agency effect* driven by competing-contracts. Of course, the tension between the effects discussed above plays a crucial role in determining the relationship between industry costs and product market competition. In order to assess the magnitude of each effect, we compute the derivative of $e^p(\theta_H)$ with respect to b,

$$\frac{\partial e^p(\theta_H)}{\partial b} = -\frac{A-\theta_L}{(1+b)^2} + \frac{2-\mu}{(\mu+b)^2}. \tag{20}$$

The first term in equation (20) captures the scale effect and is negative, the second one is positive and stands for the pure agency effect. Intuitively, when products become more close substitutes, effort reduces simply because production is less profitable. Nonetheless, an increase in b reduces the information rents granted to efficient types thus allowing owners to increase the effort exerted by inefficient managers, everything else being kept constant.[20] Of course, the net effect will depend on: (i) the *intensity* of product market competition, measured by the degree of products' substitutability, b; (ii) the relative *likelihood* of inefficient managers, μ; and (iii) the measure of the *market profitability*, $A-\theta_L$. Next proposition formalizes the result:

Proposition 2 *Assume $c^p(\theta_H) > 0$ and take any $\mu \in (0,1)$,then there exists $\bar{k}_\mu > 0$ such that: (i) if $A-\theta_L < \bar{k}_\mu$, $e^p(\theta_H)$ is inverted-U shaped, i.e., it is strictly concave in b with a maximum at $\bar{b}_\mu \in [0,1)$; (ii) if $A-\theta_L \geq \bar{k}_\mu$, $e^p(\theta_H)$ is monotonically decreasing in b; (iii) $\bar{k}_{\mu_1} \leq \bar{k}_{\mu_2}$ for all $\mu_1 \geq \mu_2$.*

The intuition for the result is easily provided. From equation (20) one can see that the relative magnitude of the scale effect is larger if the market profitability increases. In fact, when there are few rents to be shared out from the market, i.e., $A-\theta_L$ low, more competition may lead firms' owners to increase the effort exerted by inefficient mangers. When the market is profitable enough, i.e., $A-\theta_L$ large, this effect weakens and the scale effect always overcomes the pure agency effect. Of course, in the former case, the relative magnitude of the scale effect is increasing with b, meaning that the incentive to reduce costs is strong when competition is sufficiently weak. Finally, as stated in part (iii), it is also worth noticing that the relative magnitude of the pure agency effect is decreasing in the measure of inefficient managers in the economy. Intuitively, when unfavorable realizations of the production

[20] This can be seen more formally from IC_L in program $\mathcal{P}_i^p$.

technology are relatively more likely than favorable ones, owners do not need to distort much the effort exerted by inefficient managers from the first-best level in order to separate types, thus weakening the competing-contracts effect. Interestingly, the result seems to capture the evidence produced in Aghion et al. (2005) showing the existence of an inverted-U shaped relationship between competition and innovation in the U. K. industries during the period of liberalization reforms undertaken over the 1970s and 1980s.

One can also show that the effect characterized above *may* be so strong to drive expected costs at industry level to assume a U-shaped form. Let $\bar{\theta} = \mu\theta_H + (1-\mu)\theta_L$, $\bar{e}^p = \sum_{\theta\in\Theta} \Pr(\theta)e^p(\theta)$ and $\bar{c}^p = \bar{\theta} - \bar{e}^p$. Next proposition provides conditions under which $\bar{c}^p$ is also non-monotonic with respect to b.

Corollary 2 *Assume $c^p(\theta_H) > 0$ and take any $\mu \in (0,1)$, then there exists a positive number $\hat{k}_\mu < \bar{k}_\mu$ such that: (i) if $A - \theta_L < \hat{k}_\mu$, $\bar{c}^p$ is U-shaped, i.e., it is strictly convex in b with a minimum at $\hat{b}_\mu \leq \bar{b}_\mu$; (ii) if $A - \theta_L > \hat{k}_\mu$, $\bar{c}^p$ is monotonically increasing in b; (iii) $\hat{k}_{\mu_1} \leq \hat{k}_{\mu_2}$ for all $\mu_1 \geq \mu_2$.*

The economic interpretation for this result is similar to the one we have provided for Proposition 2 above, thus it will be omitted.

Finally, next proposition shows that while information rents are decreasing with respect to b under a cost-target regime, they may well follow an inverted-U shaped relationship under profit-target.

Proposition 3 *The information rents $\varphi(e^c(\theta_H))$ and $\vartheta(e^p(\theta_H))$ satisfy the following properties: (i) $\varphi(e^c(\theta_H))$ is monotonically decreasing in b; (ii) for any given $\mu \in (0,1)$ there exists $\check{k}_\mu > 0$ such that: if $A - \theta_L < \check{k}_\mu$ then $\vartheta(e^p(\theta_H))$ is inverted-U shaped, i.e., it is strictly concave in b, with a maximum at $\check{b}_\mu \in [0,1)$; if $A - \theta_L \geq \check{k}_\mu$, then $\vartheta(e^p(\theta_H))$ is monotonically decreasing in b; (iii) $\check{k}_{\mu_1} \leq \check{k}_{\mu_2}$ for all $\mu_1 \geq \mu_2$.*

The economic intuition for part (i) is straightforward. As we have seen before, the effort level exerted by inefficient managers under cost-target decreases with b, information rents must then follow the same pattern since they increase with respect to effort. As for part (ii), one must consider two effects. First, as above, b has an indirect impact via effort. Second, information rents may also vary because of the competing-contracts effect. While the former effect may be ambiguous depending on the conditions provided in Proposition 2, one can easily verify that the latter one goes in the direction of reducing information rents.

6 Discussion

Throughout the paper we made two main simplifying assumptions. First, the analysis has been carried out under the assumption of discrete types. Second, we assumed perfect (positive) correlation between managers' types. Moreover, we have focused only on symmetric equilibria. As we now explain, the results of the paper can be generalized by relaxing both these assumptions.

Continuum of Types Introducing a continuum of types does not change qualitatively our results, though it notably complicates their formal derivation.[21] In fact, the driving force of our results, a competing-contracts effect emerging under profit-target contracts, would still be at play with a compact support of types.[22] In this case, however, to obtain tractable close form solutions, one should impose quite restrictive assumptions on the distribution of types. Hence, besides adding unnecessary analytical complications, such restrictions would also weaken the robustness of the analysis.

Correlated Types When relative performance are unenforceable, introducing correlated types does not qualitatively change our results provided that the correlation between managers' types is positive and sufficiently large. The proof of this claim is based on a simple continuity argument holding for the case of Bayes-Nash implementation due to imperfect correlation. Indeed, the optimization programs $\mathcal{P}_i^c$ and $\mathcal{P}_i^p$ would display objective functions, revelation and participation constraints continuous in the measure of correlation.

Asymmetric Equilibria Throughout the paper we have studied only symmetric equilibria of the game $\mathcal{G}$. One may wonder whether, besides the results characterized in Proposition 1, there exist some asymmetric equilibria where owners end up playing different types of contracts. We believe that, although from a purely theoretical viewpoint the question is per se an interesting one[23], it would not add new qualitative insights to the results already stated in the paper. Indeed the presence of

[21] Especially for what concerns the proof of Proposition 1 which is a central result of the paper.

[22] This can be readily showed by adapting the formal analysis performed in Martimort (1996) to our framework including a moral hazard component.

[23] It is possible to show that, under some configuration of the parameters of the model, asymmetric equilibria may indeed exist.

asymmetric equilibria would only reinforce the finding that the observed heterogeneity of governance arrangements in managerial firms can be rationalized by agency theory in a competing organization set-up with unobservable contracts.

7 Concluding Remarks

We have analyzed the relationship between managerial incentives and product market competition in a principal-agent perspective. The analysis has considered an environment where firm owners endogenously design the type of contractual arrangements determining the organization structure of their firms. Under adverse selection and moral hazard, owners are asked to choose between cost-based and profit-based managerial rewards in order to shape the rent extraction-efficiency trade-off. Two assumptions are key to our results: (i) common components in the managers' private information; (ii) inability to enforce relative performance schemes.

In characterizing the set of equilibrium contracts, we have proved that this set is non trivially affected by the degree of product market competition. It is shown that profit-target contracts are always a symmetric Nash equilibrium of the game, whereas cost-target contracts (whose study has been often the focus of the literature on optimal managerial contracts) may only be when the degree of product market competition is large enough and favorable realization of the production technologies are relatively more likely than unfavorable ones. This result is important for two main reasons: (i) it shows that the analysis of the relationship between competition and incentives focused on cost-target contracts (see Raith, 2003, Schmidt, 1997, Stennek, 2000) overlooks important effects since profit-target and cost-target contracts have different implications for the equilibrium allocation in imperfectly competitive industries; (ii) it shows that the principal-agent paradigm is not at odds with the evidence that managerial rewards are often not based on firms' performance. In this respect, one could argue that public policies affecting the relative cost of alternative contracting regimes can have significant impact on owners' equilibrium incentives and, in turn, on social welfare. In a simple extension of the present model, where verifiability of different pieces of information may only be obtained at a positive fixed cost, any policy enhancing transparency of accounting profits relative to operation costs may drive shareholders to select the constrained Pareto optimal remuneration scheme.

We have also argued that when owners choose to condition managerial compensation on costs, a direct measure of managers' effort, the standard inverse relationship between market competition and effort obtains. If, instead, owners adopt compensation schemes based on profits, a contracting externality directly affects the revelation constraints needed to guarantee truthful revelation of types. In this latter case, a competing-contracts effect à la Martimort (1996) changes owners' view of the trade off between rent extraction and efficiency, relative to cost-target contracts, requiring larger effort and production levels assigned to inefficient managers, a view which has been recently supported by U. K. data.

Of course, the results in the paper are subject to few caveats, since they where derived for a simple contract set available to owners (either cost or profit target have to be chosen). Further investigations on the robustness of our results for richer contract space available to owners may be worth doing. However, to the extent that the competing-contracts effect survives in imperfectly competitive environments, we believe that the basic points extend to more general contracting technologies, provided that yardstick competition is not enforceable.

References

[1] Aghion, P., Bloom, N., Blundell, R., Griffith, R., Howitt, P., "Competition and Innovation: An Inverted-U Relationship", *The Quarterly Journal of Economics,* 120: pp. 701-728, 2005.

[2] Bebchuk L.A., and Fried, J.M., "Executive Compensation as an Agency Problem", *Journal of Economic Perspectives,* 17: pp. 71-92, 2003.

[3] Bebchuk L.A., and Fried, J.M. and Walker D.I., "Managerial Power and Rent Extraction in the Design of Executive Compensation", *The University of Chicago Law Review*, 69: pp. 751-846, 2002

[4] Bertoletti P. and Poletti C., "X-Inefficiency, Competition and Market Information" *The Journal of Industrial Economics*, 45: pp. 359-375, 1997.

[5] Bertoletti P. and Poletti C., "On Endogenous Efficiency in Public and Private Firms" *Journal of Economic Theory*, 3: pp. 273-284, 1997.

[6] Bontems, P. and Bourgeon, J. M., "Creating Countervailing Incentives through the Choice of Instruments", *Journal of Public Economics*: 76, pp. 181-202, 2000.

[7] Caillaud, B., Jullien, B. and Picard, P., "Competing Vertical Structures: Precommitment and Renegotiation", *Econometrica,* 59: pp. 595-615, 1995.

[8] Celentani M., and Loveira R., "What Form of Relative Performance Evaluation" mimeo 2004.

[9] Cuñat, V., and Guadalupe, M., "How Does Product Market Competition Shape Incentives Contracts", mimeo 2002.

[10] Crémer J., and McLean R.P., "Full Extraction of the Surplus in the Bayesian and Dominant Strategy Auctions", *Econometrica,* 56: pp. 1247-1257, 1988.

[11] Fershtman, C., and Judd, K., "Equilibrium Incentives in Oligopoly", *American Economic Review*, 77: pp. 551-559, (1987).

[12] Galdón-Sánchez, J., and Schmitz, J., "Competitive Pressure and Labor Productivity: World Iron-Ore Markets in the 1980's", *American Economic Review*, 92: pp. 1222-1235, 2002.

[13] Hart, O.D., "The Market as an Incentive Scheme", *The Bell Journal of Economics*, 14: pp. 366-382, 1983.

[14] Hermalin, B.E., "The Effects of Competition on Executive Behavior" *RAND Journal of Economics*, 23: pp. 350-365, 1992.

[15] Jensen M., and Meckling W., "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure" *Journal of Financial Economics,* 3: pp. 305-360, 1976.

[16] Jullien, B., "Participation Constraints in Adverse Selection Models", *Journal of Economic Theory,* 93: pp. 1-47, 2000.

[17] Katz, M.L., "Game-Playing Agents: Unobservable Contracts as Precommitments", *RAND Journal of Economics*, 22: pp. 1-31, 1991.

[18] Knittel, C.R., "Alternative Regulatory Methods and Firm Efficiency: Stochastic Frontier Evidence from the US Electricity Industry" *The Review of Economics and Statistics,* 84(3): pp. 523-540, 2002.

[19] Laffont, J.J., and Tirole, J., "Using Cost Observation to Regulate Firms", *Journal of Political Economy,* 94: pp. 614-641, 1986.

[20] Laffont, J.J., and Tirole, J., *A Theory of Incentives in Procurement and Regulation,* MIT Press, Cambridge, 1993.

[21] Laffont, J.J., and Martimort, D., *The Theory of Incentives, The Principal-Agent Model*, Princeton University Press, 2002.

[22] Maggi, G., and Rodriguez-Clare, A., "On Countervailing Incentives", *Journal of Economic Theory*, 66: pp.238-63, 1995.

[23] Martimort, D., "Exclusive Dealing, Common Agency, and Multiprincipals Incentive Theory", *RAND Journal of Economics*, 27: pp. 1-31, 1996.

[24] Martimort, D., and Piccolo, S., "Resale Price Maintenance under Asymmetric Information" mimeo CSEF and IDEI, October 2005.

[25] Martimort, D., and Piccolo, S., "The Strategic Value of Incomplete Contracting" mimeo CSEF and IDEI, February 2006.

[26] Martin, S., "Endogenous Firm Efficiency in a Cournot Principal-Agent Model", *Journal of Economic Theory*, 59: pp. 445-450, 1993.

[27] Murphy, K.J., "Executive Compensation" in O. Ashenfelter and D. Card, *Handbook of Labor Economics,* Vol 3, North Holland, Amsterdam, 1999.

[28] Myerson, R., "Optimal Coordination Mechanisms in Generalized Principal-Agent Problems", *Journal of Mathematical Economics*, 10: pp. 67-81, 1982.

[29] Nalebuff, B.J., and Stiglitz J.E., "Information Competition and Markets", *American Economic Review*, 73: pp. 724-746, 1983.

[30] Nickell, S., "Competition and Corporate Performance", *Journal of Political Economy*, 104: pp. 724-746, 1996.

[31] Prat, A., and Rustichini, A., "Games Played through Agents", forthcoming in *Econometrica.*

[32] Raith, M., "Competition, Risk and Managerial Incentives", *American Economic Review*, 93: pp. 1425-1436, 2003.

[33] Riordan, M. H., and Sappington D., "Optimal Contracts with Public ex post Information", *Journal of Economic Theory*, 45: pp. 189-199, 1988.

[34] Sappington, D., "Price Regulation and Incentives," in Handbook of Telecommunications Economics, Vol. I, Martin Cave, Sumit Majumdar, and Ingo Vogelsang, eds. Amsterdam: North Holland, pp. 225-293.", 2002.

[35] Scharfstein D., "Product Market Competition an Managerial Slack", *RAND Journal of Economics*, 19: pp. 147-155, 1988.

[36] Schmidt, K., "Managerial Incentives and Product Market Competition". *Review of Economic Studies,* 64: pp 191-213, 1997.

[37] Sklivas, S.D., "The Strategic Choice of Managerial Incentives" *RAND Journal of Economics*, 18: pp. 452-458, 1987.

[38] Stennek, J., "Competition Increases X-efficiency - A Limited Liability Mechanism", *European Economic Review*, 44: pp 1727-1744, 2000.

[39] Varian, H. R., "Entry and Cost Reduction", mimeo, 1994.

[40] Vives, X., "Innovation and Competitive Pressure", mimeo, 2005.

8 Appendix

Incentive Feasible Allocations under Cost-Target

Standard algebraic manipulations yield (2)-(4). By adding up IC_L and IC_H, one can verify that any allocation which satisfies simultaneously (3) and (4) must also satisfy the monotonicity condition $1 \geq e_i(\theta_H) - e_i(\theta_L)$. So that, whenever one of the two incentive compatibility constraints holds as an equality and the above inequality is satisfied too, it is immediate to show that the other IC constraint must hold too. The i-th owner chooses a contract so to maximize the following maximization program:

$$\begin{cases} \max_{\langle c_i(.),q_i(.),u_i(.)\rangle_{\theta\in\Theta}} -(1-\mu)\varphi(e_i(\theta_H)) + \sum_{\theta\in\Theta}\Pr(\theta)\left\{\tau_i(\theta)q_i(\theta) - \psi(e_i(\theta))\right\} \\ \\ s.t.,\ q_i(\theta)\geq 0,\, 0\leq c_i(\theta)\leq\theta,\text{ for every }\theta\in\Theta, \end{cases} \tag{21}$$

whose first-order conditions yield immediately first-order conditions (8)-(11). Since IC_L and PC_H together imply PC_L, the solution of (21) also optimizes program $\mathcal{P}_i^c$ if IC_H holds at the equilibrium allocation.

Proof of Lemma 2

Part (i) The claim easily follows by linearity of both $p_i(.)$ and $C(.)$, and convexity of $\psi(.)$.

Part (ii) PC_L is satisfied by construction at the allocation $\{q^c(\theta), e^c(\theta)\}_{\theta\in\Theta}$. In order to show that IC_H holds it suffices to verify that $1\geq e^c(\theta_H)-e^c(\theta_L)$. Using equation (12) the proof follows.

Part (iii) First, note that $A>\theta_H+3(1-\mu)/\mu \Rightarrow e^c(\theta_H)>0$ for all b, which in turn implies $q^c(\theta_H)>0$ since $0<e^c(\theta_H)<q^c(\theta_H)$ for all b. Moreover, to have $c^c(\theta)>0$ one also needs $e^c(\theta)<\theta$ for all b and θ, which immediately follows as we have assumed $A<2\theta_L$. Finally, observe that $\theta_L>1+3(1-\mu)/\mu$ implies $\mathcal{I}\neq\varnothing$.

Part (iv) The claim follows by using (1), (12) and (13) together. □

Incentive Feasible Allocations under Profit-Target

As above, standard algebraic manipulations allow to obtain equations (5)-(7). Let,

$$\Phi\left(\{\tau_i(\theta),q_i(\theta)\}_{\theta\in\Theta}\right)\equiv\int_{\tau_i(\theta_H)+q_i(\theta_H)}^{\tau_i(\theta_L)+q_i(\theta_L)}\int_{\theta_L+q_j(\theta_L)}^{\theta_H+q_j(\theta_H)}\psi''(t+s-A)dtds$$

by adding up IC_L and IC_H we get a *modified* monotonicity condition:

$$1\gtreqless\varkappa(\mathbf{q}_j)\text{ and }\tau_i(\theta_L)+q_i(\theta_L)\gtreqless\tau_i(\theta_H)+q_i(\theta_H). \tag{22}$$

Once again, if an allocation satisfies one of the two incentive compatibility constraints with equality and (22), then also the other IC constraint must be satisfied. The i-th owner chooses a mechanism so to maximize the following maximization program:

$$\begin{cases} \max_{\langle \tau_i(.),q_i(.),u_i(.)\rangle_{\theta\in\Theta}} -(1-\mu)\vartheta(e_i(\theta_H)) + \sum_{\theta\in\Theta}\Pr(\theta)\left\{\tau_i(\theta)q_i(\theta)-\psi(e_i(\theta))\right\} \\ \\ s.t.,\ q_i(\theta)\geq 0,\ \tau_i(\theta)\geq\ ,\ 0\leq e_i(\theta)\leq\theta,\ \text{for every } \theta\in\Theta, \end{cases} \tag{23}$$

whose first-order conditions immediately yield first-order conditions (14)-(17). One can note that, by conjecturing $1 \geq \varkappa(\mathbf{q}_j^p)$ at the equilibrium allocation, PC_H and IC_L together imply PC_L. Hence, in order to show that the solution of (23) also optimizes program $\mathcal{P}_i^p$, one only needs to show that IC_H is satisfied at the equilibrium allocation.

Proof of Lemma 3

Part (i) The proof immediately follows by the linearity of τq and convexity of $\psi(.)$.

Part (ii) PC_L holds by construction at the equilibrium allocation. Moreover, to show that IC_H holds too, it is enough checking that the pair $(q^p(\theta_L), q^p(\theta_H))$ satisfies (22). Let $\Gamma(\mathbf{q}_j) \equiv 1-\varkappa(\mathbf{q}_j)$, since $q^p(\theta_L) > q^p(\theta_H)$, equation (22) holds if $\Gamma(\mathbf{q}^p) \geq 0$ for all b. Simple algebra allows, indeed, to show that $\Gamma(\mathbf{q}^p) = \mu/(b+\mu) > 0$, which proves the claim.

Part (iii) The proof follows immediately since by Corollary 4 a sufficient condition for $\mathcal{P}_i^p$ to display interior solutions is that $q^c(\theta_H) > 0$ and $e^c(\theta_H) > 0$ for all b.

Part (iv) Equations (1), (18) and (19) together immediately imply the claim. □

Proof of Lemma 4

The proof of part (i) is straightforward. Moreover, since we have assumed internal solutions, by using (12), (13), (18) and (19) simple algebraic manipulations yield:

$$q^p(\theta_H) - q^c(\theta_H) = \frac{b(1-\mu)}{\mu(\mu+b)(1+b)} \geq 0, \quad e^p(\theta_H) - e^c(\theta_H) = \frac{b(1-\mu)(2+b)}{\mu(\mu+b)(1+b)} \geq 0, \tag{24}$$

which immediately proves part (ii). □

Proof of Proposition 1

To begin with, it is worthwhile observing that the maximization programs solved by the i-th owner under the two types of contracts can be rewritten as:

Cost-Target:

$$\begin{cases} \max_{\langle e_i(.),q_i(.),u_i(.)\rangle_{\theta\in\Theta}} \sum_{\theta\in\Theta} \Pr(\theta)\left\{(p_i(q_i(\theta),q_j(\theta))-(\theta-e_i(\theta)))q_i(\theta)-\psi(e_i(\theta))-u_i(\theta)\right\} \\ \\ \qquad s.t.,\ (2)-(4),\ q_i(\theta)\geq 0,\ 0\leq c_i(\theta)\leq\theta,\ \text{for every } \theta\in\Theta. \end{cases} \tag{25}$$

Profit-Target:

$$\begin{cases} \max_{\langle e_i(.),q_i(.),u_i(.)\rangle_{\theta\in\Theta}} \sum_{\theta\in\Theta} \Pr(\theta)\left\{(p_i(q_i(\theta),q_j(\theta))-(\theta-e_i(\theta)))q_i(\theta)-\psi(e_i(\theta))-u_i(\theta)\right\} \\ \\ \qquad s.t.,\ (5)-(7),\ q_i(\theta)\geq 0,\ \tau_i(\theta)\geq\ ,\ 0\leq e_i(\theta)\leq\theta,\ \text{for every } \theta\in\Theta. \end{cases} \tag{26}$$

Notice that, for any given pair $(q_j(\theta_L), q_j(\theta_H))$, programs (25) and (26) display the same objective function but different sets of constraints. Hence we can use a simple revealed preferences argument to show that if the allocation solving program (26) is feasible in (25), i.e., it satisfies (2)-(4), then the i-the owner must be better off under cost-target relative to profit-target (the converse is obviously also true).

Part (i) The claim is proved in three steps.

Step 1 *Profit-target must be a symmetric equilibrium of the game $\mathcal{G}$ for all $(b,\mu)\in[0,1]^2$.*

Proof In order to prove the claim we need to show that the allocation implemented by the i-th owner under cost-target is incentive feasible under profit-target, conditional on her rival playing profit-target. Let $q_j(\theta) = q^p(\theta)$, $e_j(\theta) = e^p(\theta)$ for all θ, by using (8)-(11) one can show that the optimal (deviation) allocation under cost-target for the i-th owner entails first-best in the low-cost state. $q_i^d(\theta_L) = e_i^d(\theta_L) = q^*(\theta_L)$. Moreover, in an (interior) incentive feasible solution, in the high-cost state one gets:

$$q_i^d(\theta_H) = q^*(\theta_H) - \frac{1-\mu}{\mu}\times\frac{\mu+(1+b)b}{(1+b)(\mu+b)}, \quad e_i^d(\theta_H) = q_i^d(\theta_H) - \frac{1-\mu}{\mu},$$

where one can easily show that monotonicity conditions hold at this allocation so that types separation is guaranteed. In order to complete the step we need to show that this allocation satisfies (22), meaning that both inequalities: $1 - \varkappa(\mathbf{q}_j^p) \geq 0$ and $q^*(\theta_L) \geq q_i^d(\theta_H)$ must hold. Suppose that $0 < e_i^d(\theta_H) < \theta_H$ for some pairs $(b, \mu) \in B$ with $B \subset [0,1]^2$. First, note that as $\mu + (1+b)b > 0$, it follows that $q_i^d(\theta_H) < q^*(\theta_H) < q^*(\theta_L)$ for all b. Then, observe that $1 - \varkappa(\mathbf{q}_j^p) = \mu/(\mu + b) > 0$. The same holds immediately with corner solutions, i.e., $e_i^d(\theta_H) = \theta_H$ or $e_i^d(\theta_H) = 0$ for some pairs $(b, \mu) \in \bar{B}$ with $B \cup \bar{B} = [0,1]^2$ and $B \cap \bar{B} = \varnothing$.

A simple revealed preferences argument, finally, allows to show that profit-target is always an equilibrium of the game and concludes the step.

Step 2 *Profit-target is always a profitable deviation for the i-the owner whenever $\mu \geq 1/2$, conditional on her rivals playing the (equilibrium) allocation obtained under a cost-target regime.*

Proof We use the same logic as above. Let $q_j(\theta) = q^c(\theta)$ and $e_j(\theta) = e^c(\theta)$ for all θ. The claim can be showed if the i-th owner has an incentive to play profit-target for all b whenever $\mu \geq 1/2$. It is then enough arguing that the allocation obtained when both owners play cost-target, $\{e^c(\theta), q^c(\theta), w^c(\theta)\}_{\theta \in \Theta}$, satisfies condition (22). So the following properties must hold: $1 - \varkappa(\mathbf{q}_j^c) \geq 0$ and $q^c(\theta_L) > q^c(\theta_H)$ for every $b \in [0,1]$. The latter inequality is obviously true; the former one rewrites as $0 \leq 1 - b/(1+b)\mu$ which holds for all $b \leq \mu/(1-\mu) = b_\mu^*$. Moreover, since $\mu \geq 1/2$ it follows that $b_\mu^* \geq 1$, hence $b \leq b_\mu^*$ holds for every $b \in [0,1]$. A simple revealed preferences argument allows to conclude the step.

Step 3 *Assume $\mu < 1/2$, then deviating to profit-target is individually profitable for the i-th owner for all $b \leq b_\mu^*$, provided that her competitor plays the (equilibrium) allocation obtained under cost-target.*

Proof First, observe that $\mu < 1/2 \Rightarrow 0 \leq b_\mu^* < 1$. As demonstrated above, at $q_j(\theta) = q^c(\theta)$ and $e_j(\theta) = e^c(\theta)$ for all θ, the i-th owner has an incentive to play profit-target for $b \leq b_\mu^*$.

Finally, gathering steps 1, 2 and 3 the claim follows immediately. □

Part (ii) Since in part (i) we have proved that profit-target is always an equilibrium of $\mathcal{G}$, we now demonstrate that cost-target is also an equilibrium of $\mathcal{G}$ for all $(b, \mu) \in \Xi$. Two simple steps demonstrate the claim.

Step 1 *Cost-target contracts are an equilibrium of $\mathcal{G}$ when the following properties hold: (i) $b > b_\mu^*$*

and $\mu \in [1/3, 1/2]$*; (ii)* $b \in (b^*_\mu, 2b^*_\mu]$ *and* $0 < \mu < 1/3$.

Proof We now need to demonstrate that the (deviation) allocation obtained under profit-target for the i-th owner is incentive feasible under cost-target, provided that her rival plays the (equilibrium) allocation obtained under a cost-target regime. To do so, we first need to characterize the (deviation) allocation played by the i-th owner under profit-target when $q_j(\theta) = q^c(\theta)$ and $e_j(\theta) = e^c(\theta)$ for all θ. Notice that when $b > b^*_\mu$ the optimal deviation entails countervailing incentives since $1 - \varkappa(\mathbf{q}^c_j) < 0$. One can see that IC_H and PC_L bind, while IC_L and PC_H are slack in program $\mathcal{P}^p_i$, so that the high-cost type is now earning information rents. The i-th owner must design a contract so to optimize the following (relaxed) maximization program:

$$\begin{cases} \max_{\langle \tau_i(.), q_i(.), u_i(.)\rangle_{\theta\in\Theta}} \sum_{\theta\in\Theta} \Pr(\theta) \left\{ \tau_i(\theta) q_i(\theta) - \psi(e_i(\theta)) - u_i(\theta) \right\} \\ \\ s.t., \ \mathrm{IC}_H \text{ and } \mathrm{PC}_L \ , \ q_i(\theta) \geq 0, \ \tau_i(\theta) \geq \ , \ 0 \leq e_i(\theta) \leq \theta \text{ for every } \theta \in \Theta, \end{cases} \tag{27}$$

where constraints IC_H and PC_L are those displayed in program $\mathcal{P}^p_i$ and the former one must be evaluated at $q_j(\theta) = q^c(\theta)$ for all θ. Let $\left\{ q^D_i(\theta), e^D_i(\theta), w^D_i(\theta) \right\}_{\theta\in\Theta}$ be the solution of (27). Assuming interior solutions, standard optimization techniques yield:

$$q^D_i(\theta_H) = e^D_i(\theta_H) = e^*(\theta_H) + \frac{b}{1+b} \times \frac{1-\mu}{\mu},$$

$$q^D_i(\theta_L) = q^*(\theta_L) - \frac{1}{1-\mu} \times \frac{b}{1+b} - \frac{\mu}{1-\mu}, \quad e^D_i(\theta_L) = e^*(\theta_L) - \frac{2}{1-\mu} \times \frac{b}{1+b} - \frac{2\mu}{1-\mu}.$$

Of course, this allocation satisfies incentive compatibility and participation constraints by construction since one can check that $q^D_i(\theta_L) < q^D_i(\theta_H)$ under the restrictions imposed in the paper. The step can now be concluded by showing that the allocation $\left\{ q^D_i(\theta), e^D_i(\theta), w^D_i(\theta) \right\}_{\theta\in\Theta}$ satisfies the monotonicity condition under cost-target. After some algebraic manipulations one gets $1 \geq (e^D_i(\theta_H) - e^D_i(\theta_L))$ if $b \leq 2b^*_\mu$. This immediately proves the claim for $\mu \in [1/3, 1/2]$ as $\mu \geq 1/3 \Rightarrow 2b^*_\mu \geq 1$, and for $b \in \left[b^*_\mu, 2b^*_\mu\right]$ if $\mu < 1/3$.

Step 2 *Cost-target is an equilibrium when* $0 < \mu < 1/3$ *and* $b \in (2b^*_\mu, 1]$.

Proof Let $\Delta\pi_i(b, \mu) = \pi^{c,c}_i - \pi^{p,c}_i$ denote the difference between the expected profits accruing to the i-th owner at the candidate equilibrium and when she deviates to profit-target, respectively. Observe that, for any given $\mu \in (0, 1)$, $\Delta\pi_i(b, \mu)$ is a continuos function of b since we have showed that programs $\mathcal{P}_i^c$ and (27) display interior solutions. After some algebraic manipulations we obtain:

$$\Delta\pi_i(b, \mu) = \frac{F(b, \mu)}{-\mu(1-\mu)(1+b)^2},$$

where $F(b, \mu) \equiv -2 + b^2(1-\mu)^2 + \mu(3 + 2(1-\mu)(A - \theta_L) + \mu) - 2b(1-\mu^2)$. It follows then that $sign(\Delta\pi_i(b, \mu)) = -sign(F(b, \mu))$ since $(1-\mu)(1+b)^2\mu > 0$ for all pairs (b, μ). By step 2 we know that $\Delta\pi_i(b, \mu) \geq 0$ for $b \in \left[b_\mu^*, 2b_\mu^*\right]$ and $0 < \mu < 1/3$, it must be then $F(b, \mu) \leq 0$ at $b = 2b_\mu^*$. Next, observe that for $\mu < 1/3$ the function $F(., \bar{\mu})$ is strictly convex for any fixed $\bar{\mu}$ and displays a global minimum at $b^m = (1-\mu^2)/(1-\mu)^2 \geq 1$, by a continuity argument it then follows that $sign(F(b, \mu)) = sign(F(2b_\mu^*, \mu))$ for all $b \leq b^m$. The proof is completed since $F(2b_\mu^*, \mu) \leq 0 \Rightarrow \Delta\pi_i(b, \mu) \geq 0$ for all $b \leq 1$.

Gathering steps 1 and 2, the claim follows immediately. □

Proof of Corollary 1

To begin with, notice that we have considered a simple representative consumer economy where, for any given wealth level ω, inverse demand functions obtain by the solution of program,

$$\max_{(q_i, q_j, I)} \left\{V(\mathbf{q}, I, \theta) : \mathbf{pq} + I \leq \omega\right\},$$

with $\mathbf{q} = (q_i, q_j)$, $\mathbf{p} = (p_i, p_j)$ and:

$$V(\mathbf{q}, I, \theta) = \theta(q_i + q_j) - \frac{1}{2}\left(q_i^2 + q_j^2 - 2bq_iq_j\right) + I,$$

So, let $V^t(\theta) = V(\mathbf{q}^t(\theta), \omega - \mathbf{p}^t(\theta)\mathbf{q}^t(\theta), \theta)$ define the measure of the state contingent consumers' well being in any symmetric play of $\mathcal{G}$ where both owners implement the contractual regime $\mathcal{C}^t \in \mathcal{S}$. Then after simple manipulations we have:

$$V^{t,t}(\theta) = 2\theta q^t(\theta) - (1-b)q^t(\theta)^2 + \omega - 2p^t(\theta)q^t(\theta) = q^t(\theta)^2, \quad \text{for every } t \in \{p, c\}, \ \theta \in \Theta.$$

Hence, by using Corollary 4 it is easy to verify that $V^{p,p}(\theta) \geq V^{c,c}(\theta)$ for all b. Taking expectations on both sides one immediately shows the first part of the claim.

Next, let $u^{t,t}(\theta)$ the information rents accruing to each manager's type in a contractual regime where both owners symmetrically implement $\mathcal{C}^t \in \mathcal{S}$ with $t \in \{c, p\}$, and denote:

$$W^{t,t} = 2\left(\sum_{\theta\in\Theta} \Pr(\theta)\left[\frac{V^{t,t}(\theta)}{2} + \pi^{t,t}(\theta) + u^{t,t}(\theta)\right]\right),$$

the expected total welfare in each market, with $\Delta W = W^{p,p} - W^{c,c}$, one can easily show that:

$$sign(\Delta W) = sign[3(q^p(\theta_H))^2 - \psi(e^p(\theta_H)) - (3(q^c(\theta_H))^2 - \psi(e^c(\theta_H)))].$$

By using equations (11), (17), and (24) together,

$$\Delta W = \frac{b(1-\mu)}{\mu(\mu+b)(1+b)}\left((1-b)(q^p(\theta_H) + q^c(\theta_H)) + \frac{1-\mu}{\mu} \times \frac{2\mu+b}{\mu+b}\right), \tag{28}$$

the result then follows from (28) since $b \leq 1$ and $q^p(\theta_H) + q^c(\theta_H) > 0$. Finally, notice that for $b = 0$ one immediately has $\Delta W = 0$ and $V^p(\theta) = V^c(\theta)$ for all θ, hence the result. $\square$

Proof of Proposition 2

Part (i) By using equation (20) one can show that $\partial e^p(\theta_H)/\partial b \gtreqless 0$ rewrites as:

$$\frac{(2-\mu)(1+b)^2}{(\mu+b)^2} \gtreqless A - \theta_L.$$

Denote $g(b,\mu)$ the left-hand-side of the above equation, simple algebra allows to obtain: $g(0,\mu) = \frac{2-\mu}{\mu^2}$, $g(1,\mu) = \frac{4(2-\mu)}{(1+\mu)^2}$, and $\frac{\partial g(b,\mu)}{\partial b} = -\frac{2(1+b)(2-\mu)(1-\mu)}{(\mu+b)^3} < 0$ for all b. Then, as $g(0,\mu) > g(1,\mu) > 0$ for every $\mu \in (0,1)$ and $A < \theta_L + g(0,\mu)$, there must exist a threshold $\bar{b}_\mu \in [0,1]$ such that $\partial e^p(\theta_H)/\partial b \gtreqless 0$ if $b \lesseqgtr \bar{b}_\mu$. Hence, setting $\bar{k}_\mu = g(0,\mu)$ provides the result.

Observe also that $A < \theta_L + \bar{k}_\mu$ is not incompatible with the requirement of interior solutions, i.e., $A > \theta_H + \frac{3(1-\mu)}{\mu}$. Indeed, one can easily show that $\theta_L + \bar{k}_\mu > \theta_H + \frac{3(1-\mu)}{\mu}$ so that the range $[\theta_H + \frac{3(1-\mu)}{\mu}, \theta_L + \bar{k}_\mu]$ where the result applies is not empty. Finally, the proof of part (ii) follows immediately from the argument used above, so it is omitted; while part (iii) is readily proved since

$\bar{k}_\mu = g(0,\mu)$ and $\partial g(0,\mu)/\partial\mu < 0$ for all μ. $\square$

Proof of Corollary 2

Part (i) By using equation (20) and the definition of $\bar{e}^p$, after some algebraic manipulations, one can show that $\partial\bar{e}^p/\partial b \gtreqless 0$ rewrites as:

$$A - \theta_L \lesseqgtr -(1+b)^2 - \frac{b(1+b)^2(2+b)}{(\mu+b)^2} + \frac{2(1+b)^3}{\mu+b}.$$

Let $f(b,\mu)$ denote the right-hand-side of the above inequality, simple algebraic manipulations allow to show that $f(0,\mu) = \frac{2-\mu}{\mu}$ and $f(1,\mu) = \frac{4(2-\mu)\mu}{(1+\mu)^2}$ with $f(0,\mu) > f(1,\mu) > 0$ for all μ. Let $\xi(b,\mu) = 2b(1-3\mu) - 3b^3 - 2(1-\mu)^2 - b(3+4\mu)$, and observe that:

$$\frac{\partial f(b,\mu)}{\partial b} = \frac{(1+b)\xi(b,\mu)}{(\mu+b)^2} \le 0,\ \forall\ (b,\mu) \in [0,1]^2.$$

Indeed, it is immediate to verify that: (i) if $\mu \ge 1/3$ it follows immediately that $\xi(b,\mu) \le 0$ for $(b,\mu) \in [0,1]^2$, which implies, in turn, $\partial f(b,\mu)/\partial b \le 0$; (ii) if $\mu < 1/3$ one can show that:

$$\frac{(\mu+b)^2}{1+b}\frac{\partial f(b,\mu)}{\partial b} \le \sup_{b\in[0,1]} \xi(b,\mu) = -2\mu(1+\mu) \le 0 \Rightarrow \frac{\partial f(b,\mu)}{\partial b} \le 0,\ \forall\ (b,\mu) \in [0,1]^2,$$

setting $\hat{k}_\mu = \frac{2-\mu}{\mu}$ the result follows immediately because $\hat{k}_\mu \le \bar{k}_\mu$. Finally, the proof of part (ii) follows immediately from the argument used above, so it is omitted; while part (iii) is readily proved since $\hat{k}_\mu = f(0,\mu)$ and $\partial f(0,\mu)/\partial\mu < 0$ for all μ. $\square$

Proof of Proposition 3

Part (i) Total differentiation of $\varphi(e^c(\theta_H))$ with respect to b yields $\partial\varphi(e^c(\theta_H))/\partial b = \partial e^c(\theta_H)/\partial b$, which immediately yields the result.

Part (ii) Total differentiation of $\vartheta(e^p(\theta_H))$ with respect to b yields:

$$\frac{\mu+b}{\mu} \times \frac{\partial\vartheta(e^p(\theta_H))}{\partial b} \times \frac{\mu+b}{\mu} = \frac{\mu}{(\mu+b)^2} - \frac{e^p(\theta_H)}{\mu+b} + \frac{\partial e^p(\theta_H)}{\partial b},$$

straightforward algebraic manipulations allow then to show that:

$$\frac{\partial \vartheta(e^p(\theta_H))}{\partial b} \gtreqless 0 \text{ iff } A - \theta_L \lesseqgtr \frac{2(1+b)^2}{(\mu+b)(1+\mu+2b)} + \frac{1+b}{1+\mu+2b} + \frac{(1-\mu)(1+b)(2+b)}{(\mu+b)(1+\mu+2b)}$$

Next, denote by $h(b, \mu)$ the right hand side of the above equation, observe that $h(0, \mu) > h(1, \mu) > 0$ for all $\mu \in (0, 1)$; moreover, one can show that $\partial h(b, \mu)/\partial b \leq 0$ for all pairs (b, μ) since each addendum in $h(b, \mu)$ decreases with respect to b. Letting $\check{k}_\mu = h(0, \mu)$ the proof can be completed following the same logic used in the proof of Proposition 2. Finally, the proof of Part (iii) follows since $\check{k}_\mu = h(0, \mu)$ and $\partial \check{k}_\mu/\partial \mu = \partial h(0, \mu)/\partial \mu < 0$. $\square$