Product Market Competition and Organizational Slack under Profit-Target Contracts*

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Abstract

In a framework à la Martin (1993) we introduce a common component in the managers' private information in order to address three related questions: What is the impact of contracts that reward managers on the basis of realized profits on firms' productive and allocative efficiency relative to cost-target contracts? How do these contracts shape the relationship between competition and organizational slack? Can we then explain the existing evidence of an inverted-U shaped relationship between competition and cost-reducing activities, as documented in Aghion et al. (2005)? We show that profit-target contracts introduce a horizontal (contractual) externality between the competing firms that mitigates organizational slack and improves upon productive efficiency relative to cost-plus mechanisms. Moreover, when executive compensations are conditioned on profits, an inverted-U shaped relationship between product market competition and managerial effort obtains. Finally, we also show that when contractual instruments are endogenous, e.g., when shareholders can choose between profit- and cost-target rules, the equilibrium with profit-target contracts always exists and is the only one that survives to standard refinements.

Keywords: competing-contracts, product market competition, X-inefficiency

JEL Classification: D82, L13, L22.

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1 Introduction

Interest in the link between competition and incentives has soared over the past decades, stimulated by the pace of technological progress and worldwide liberalization and deregulation reforms. In particular, the question of whether, and to what extent, competitive pressure mitigates organizational slack has been intensely debated by scholars and policy makers. Yet, in spite of the empirical evidence, mildly supporting the conjecture that more competition spurs innovation and cost-reducing incentives[1], the theoretical literature has often expressed contrasting views on this ground. The reason for this ambiguity rests upon the complexity that incentive issues introduce in environments where ownership and management pursue diverging objectives.

Existing agency models show why intensified competitive pressure may have unclear effects on managerial effort depending on several factors including, among other things, the type of asymmetric information, the underlying information structure, managers' preferences and the chosen measure of competition (see, for instance, Laffont and Boyer, 2003). But these models do not explicitly analyze the link between contract design, competition and executive behavior. More precisely, they often ignore that alternative contractual rules may shape differently agency costs and, in turn, have a key impact on the way competition influences organizational slack.

The objective of this paper is to show how the relationship between product market competition and organizational slack depends on the type of monitoring instruments that shareholders use to control, and thus to reward, executive performance. To make this point most vividly, we study a simple duopoly model where two managerial firms compete by selling differentiated goods. All productive assets are owned by shareholders, but firms are run by managers holding specific expertise in managing production technologies. We assume that whereas shareholders design the firms' contractual structure, managers have private information on an industrywide technology shock, perform an unverifiable cost-reducing activity and control firms' production decisions. Our analysis considers two forms of managerial rewards. In the first regime, a contract is a cost-plus mechanism à la Laffont and Tirole (1986), which rewards managers on the basis of operational costs — a direct measure of their performance. In the second regime managers are rewarded on the basis of realized accounting profits — an instrument reflecting also rivals' performance. We derive the equilibrium incentive schemes in both cases and address three related questions: How does the introduction of profit-target contracts affect firms' productive and allocative efficiency relative to cost-target ones? What is the impact of these contracts on the relationship between competition and organizational slack? Can we then explain the existing evidence of an inverted-U shaped relationship between competition and cost-reducing activities, as documented in Aghion

[1] See for instance Aghion et al. (2005) and Nickell (1996) among many others.

et al. (2005)?

Understanding these questions is important for two reasons. On the one hand, it helps clarifying the role that the design of managerial incentives plays in determining firms' productivity and industry performance. On the other hand, it allows us to derive testable implications concerning the impact of alternative incentive schemes on the link between competition and incentives.

We show that competitive pressure, as measured by the degree of products' substitutability, has no direct impact on the firms' internal agency problem when contracts take the form of cost-plus mechanisms. This is so because managers' incentive constraints are independent from rivals' performance. In this regime, in fact, the agency problem faced by shareholders is formally equivalent to that emerging in a isolated principal-agent relationship. Therefore, intensified product market competition unambiguously reduces managerial effort so as to drive up marginal costs. The idea is that when products become closer substitutes, equilibrium prices scale down; this renders production less profitable and thus lowers effort incentives: a scale effect as in Martin (1993).[2]

When profits are used to control managerial effort, instead, we show that competition has a direct impact on managers' incentive constraints. A competing-contracts effect à la Martimort (1996) mitigates the agency conflict between ownership and management, thereby relaxing the standard rent extraction-efficiency trade-off. This allows shareholders to implement allocations that improve upon productive as well as allocative efficiency relative to cost-target contracts. More precisely, rewards schemes based on profits make information misrepresentation more costly for managers.

Essentially, since in this regime wages are increasing with respect to firm profits (and thus decreasing in rivals' performance) when an efficient manager overstates his type, in addition to the utility gain owing to the (effort) cost-saving effect (Laffont and Tirole, 1986), he must also bear an *implicit cost* due to the fact that, in the deviation, he is forced to produce less than his rival who truthfully reveals the state of nature. In this way, the deviating manager leaves *market stakes* to his competitor simply because mimicking has the effect of increasing the residual demand for the good produced by the competing hierarchy. Indeed, when types are perfectly correlated, by overstating his type a low-cost manager induces his shareholders to believe that the rival firm faces high costs as well and thus produces less. Under the hypothesis of Nash behavior at the revelation stage,[3] this manager knows that his rival will "tell the truth" and will thus produce more than what expected by his shareholders. Therefore, as a consequence of a misreport, he

[2] This effect has the same flavour of Hermalin (1992)'s change-in-the-relative-value-of-actions effect and Schmidt (1997)'s value-of-a-cost reduction effect.

[3] When a manager reports his message about the state of nature, he keeps as given that his rival truthfully reports the state of nature.

will have to increase effort so as to compensate the unexpected reduction in profits driven by his rival's overproduction. Clearly, this makes truthful information revelation less costly relative to the case of cost-target. Therefore, equilibrium information rents scale down and an allocation closer to the complete information benchmark can be implemented at equilibrium. Interestingly, in this framework, the standard negative externality between duopolists competing in strategic substitutes can be exploited by shareholders to improve internal control of managerial behavior.

In addition, since the competing-contracts effect becomes more intense as the degree of products' substitutability increases — the stronger is the (negative) market externality between the competing firms — a non-monotonic relationship between competition and effort in unfavorable technological states can now emerge. Indeed, in a non empty subset of parameters, a pure *agency* effect may overcome the scale effect so as to deliver an equilibrium effort level that increases with the intensity of product market competition. Interestingly, we show that when firms' internal agency problem is severe enough, this relationship is inverted-U shaped. This result implies that the agency effect is more pronounced for low levels of products' substitutability, while it is offset by the scale effect when products become closer substitutes. Intuitively, if agency costs are large relative to a measure of "profit margins", the beneficial impact of intensified competition on informational rents — and thus on effort — more than compensates the scale effect whenever demand for goods are nearly independent. This is because when competition is weak, truthful information revelation commands a rent close to that of an isolated principal-agent relationship. In this case, agency costs are so large that even small variations of products substitutability hugely relax incentive constraints through competing-contracts. Hence, the implied reduction of agency costs dominates the scale effect. Clearly, this trade-off may well point in the opposite direction when competition intensifies. The reason is that when products are close substitutes the responsiveness of the rival firm to cost fluctuations diminishes, so that the relative performance role played by the competing-contracts weakens because differences in realized profits are less sensitive to the rival's performance. In this case allocations become very close to those obtained in the cost-target regime, therefore effort must decrease with competition. This explains the inverted-U shaped result.

This conclusion provides a guidance for empirical work on the relationship between product market competition and organizational slack. In particular, our results suggest that an inverted-U shaped relationship should be more likely to be found in industries where managerial rewards are contingent on profits and incentive problems are relatively severe. Moreover, our results also imply that while competition stifles cost-reduction and R&D activities in boom phases, the opposite may happen in recessions.

Finally, in order to support the view that profit-target contracts (our main modeling innovation) are more appropriate than cost-target ones in studying the link between competition and organizational slack in games of competing hierarchies, we extend the analysis to a model where the screening instruments are endogenous. More precisely, we characterize the symmetric PBE of a game where shareholders simultaneously choose between cost- and profit-target schemes. We show the equilibrium where managers are rewarded on the basis of profits always exists, whereas cost-target rules may only emerge at equilibrium in a subset of the parameters' space. Moreover, we show that, when multiple equilibria obtain, only the one with profit-target contracts survives to the most standard equilibrium refinement criteria, i.e., Pareto and risk dominance. This equilibrium is also robust to a refinement based on constrained join-profit maximization.

The reminder of the paper is organized as follows. Section 2 reviews the literature related to our work. Section 3 sets up the model and Section 4 describes briefly the complete information benchmark. Section 5 studies the model under asymmetric information: It characterizes the optimal incentive contracts in each of the two regimes and provides our main comparative statics results. In Section 6 we extend the analysis to the endogenous screening game. Finally, Section 7 concludes. All proofs are relegated to an Appendix.

2 Related Literature

The theoretical debate on competition and incentives has an old tradition which goes back to Leibenstein's ideas. This literature has often expressed contrasting views on the way competition affects organizational slack. As observed by Boyer and Laffont (2003), understanding this issue is, in general, a very difficult task because strategic considerations may affect managerial performance in several ways (for instance through incentive constraints, participation decisions and principals' objective functions). According to their literature classification, our paper belongs to the body of work dealing with the impact of competition on incentives in adverse selection environments.[4] This strand of literature stems from the seminal contribution by Hart (1983) who showed that competition stifles managerial slack and promotes innovation in industries where managers are privately informed on a common technological shock and the measure of entrepreneurial firms in the economy is large enough. This result has been criticized by Scharfstein (1988) and Hermalin (1992) who prove that Hart's conclusions obtain only with a very large degree of managers' risk

[4] With moral hazard the positive impact of competition on managerial effort has been showed by a number of papers focusing on financial market imperfections (see Schmidt, 1997, Stennek, 2000). The key idea is that if shareholders face limited liability constraints and may not be able to pay out managers in some states of the world, competition reduces organizational slack simply because managers will be willing to reduce the probability of these 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. In a similar moral hazard framework Raith (2003) shows that whenever firms compete on the Salop circle, more competition, as measured by lower transportation costs, increases managerial effort if contracts are based on realized costs.

aversion. With a more standard preference structure, they show that results are ambiguous and may depend on a variety of effects that may well point against Hart's result. This conclusion is extreme in Martin (1993), who shows that a measure of X-inefficiency increases with the number of active firms in the market whenever contracts are based on cost reimbursement rules and shocks to firms' marginal costs are i.i.d.

Our contribution adds to this literature in two respects. First, we identify a new channel, pointing in the direction of supporting Hart's conclusions, through which product market competition affects managerial effort. This effect is purely based on incentive constraints and was overlooked in previous work. The second contribution shows that this agency effect delivers an inverted-U shaped result which is consistent with the most recent empirical evidence. In this regard, the paper has the main merit of bringing theory closer to the evidence.

As for the characterization provided in the case of endogenous screening instruments, the paper shades some new light on the channels through which product market competition affects equilibrium contractual choices in games of competing hierarchies.[5] By characterizing the equilibria of a game where principals endogenously choose managerial incentive schemes, we illustrate the effects of product market competition on this equilibrium choices and their efficiency properties. In this respect, the paper makes a step towards extending to competitive environments the agency literature on input versus output monitoring (Maskin and Riley, 1985, and Khalil and Lawarée, 1995).

Finally, it is also worth stressing the contribution of our paper with respect to Martimort (1996). Whereas this paper introduces and characterizes for the first time the competing-contracts effect in a pure adverse selection framework, our work analyzes how this effect contributes to determine the relationship between competition and cost reducing incentives in a model à la Laffont and Tirole (1986) where adverse selection is coupled with moral hazard.

3 The Model

Players and Environment: Consider an industry where two managerial firms, indexed by $i = 1, 2$, produce differentiated goods and compete by setting quantities. Shareholders own all the productive assets but have no expertise in managing them, hence they must employ self-interested managers to run the firms in their behalf. The (inverse) demand is symmetric for both markets with:

$$p_i(q_i, q_j) = A - q_i - \sigma q_j, \text{ for } i \neq j,$$

[5] More general results on the issue of endogenous screening instruments in games of competing hierarchies are presented in Martimort and Piccolo (2008).

where q_i is the quantity produced of product i, $p_i(.)$ is its final price and $\sigma \in [0, 1]$ measures the degree of products' substitutability. Firms' technologies are described by linear cost functions:

$$C_i(q_i, \tilde{\theta}, e_i) = (\tilde{\theta} - e_i)q_i, \text{ for } i = 1, 2,$$

where $\tilde{\theta}$ denotes the realization of a random variable affecting symmetrically firms' marginal costs.[6] This variable is distributed on a discrete support $\Theta \equiv \left\{\overline{\theta}, \underline{\theta}\right\}$, with probability $\Pr(\tilde{\theta} = \underline{\theta}) = \nu$, and its realization is observed only by managers. The variable e_i measures an unverifiable cost-reducing activity (effort or expertise) performed by the manager running firm i. Managerial activity is assumed to be costly and, only for simplicity, we denote with $\psi(e_i) = e_i^2/2$ the effort disutility for every manager i. All players are risk neutral. Manager i's preferences are represented by the utility function

$$U_i = w_i - \psi(e_i),$$

where w_i denotes a monetary transfer (wage) paid-out by firm i's shareholders, whose objective function is the net profit

$$\pi_i(q_i, e_i, q_j, w_i, \tilde{\theta}) = p_i(q_i, q_j)q_i - C_i(q_i, e_i, \tilde{\theta}) - w_i, \text{ with } i \neq j.$$

Throughout we shall denote by $c_i(.) = \tilde{\theta} - e_i$ firm i's marginal costs and by $\tau_i(.) = p_i(.) - c_i(.)$ its net average profits.

Contractual Regimes: We model a managerial firm as an exclusive principal-agent relationship. Shareholders (principals) hire managers (agents) before production occurs but after uncertainty is resolved, they have the full bargaining power and offer contracts through take-it-or-leave-it offers. We assume that bilateral contracts signed within each firm are secret and use the version of the Revelation Principle for games of competing hierarchies (Myerson, 1982, and Martimort, 1996) to characterize the set of incentive feasible allocations.[7] In this context, we study two alternative contractual regimes: In the first, managers are rewarded on the basis of realized **average (marginal) costs**; in the second, they are rewarded according to realized **average profits**.[8] More

[6]For instance, one can imagine that $\tilde{\theta}$ measures shocks to the cost of an essential raw input used to recover final goods from the firms' production technologies. In practice, this could be the case of "neck-and-neck" industries, where firms have similar production technologies.

[7]Indeed, with bilateral secret contracts, for any output choice made by agent j, there is no loss of generality in looking for principal i's best response within the class of direct and truthful mechanisms to characterize pure strategy equilibria.

[8]We do not consider contracts contingent on both costs and profits since we assume that, as in the literature on *input* versus *output* monitoring (Maskin and Riley, 1985, and Khalil and Lawarée, 1995, among others), a priori only one of those targets can be verified. Implicitly, this means that the (unmodeled fixed-) costs of making both

precisely, in the profit-target regime a contract is a mechanism $\mathcal{C}_i^p \equiv \{\tau_i(m_i), q_i(m_i), w_i(m_i)\}_{m_i \in \Theta}$ specifying, for each manager i's report $m_i \in \Theta$, an average profit-target, $\tau_i(.)$, a sales level, $q_i(.)$, and a monetary transfer (wage), $w_i(.)$. In contrast, in the cost-target regime a contract is a mechanism à la Laffont-Tirole, $\mathcal{C}_i^c \equiv \{c_i(m_i), q_i(m_i), w_i(m_i)\}_{m_i \in \Theta}$, dictating a cost-target $c_i(.)$ instead of a profit-target $\tau_i(.)$.[9]

Timing: Given any contractual regime, the sequence of events is as follows:

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

- **T=2** Shareholders *simultaneously* and *secretly* propose contracts to their managers. If an offer is rejected, both parties composing a vertical hierarchy enjoy their outside option, normalized to zero for simplicity.

- **T=3** A communication game takes place within each firm if contract proposals are accepted: Managers deliver messages, exert effort and produce according to the rules specified in their contracts. Finally, payments are made.

It is worth stressing that in our setting contracts are secret, meaning that for any given contractual regime the specific terms of trade enforced within a given hierarchy cannot be observed by other players. Our equilibrium concept will be Perfect Bayesian Equilibrium (PBE) with a *"passive beliefs"* refinement. More precisely, we assume that, given any candidate equilibrium profile of offers $\left(\mathcal{C}_i^{t_i}\right)_{i=1,2}$ with $t_i \in \{c, p\}$, if manager i receives any unexpected offer $\mathcal{C}_i^{t_i'} \neq \mathcal{C}_i^{t_i}$ from his shareholders, he still believes that the contract $\mathcal{C}_j^{t_j}$ is offered within the competing hierarchy and that his competitor still produces the quantity specified by such a contract. Finally, we shall also assume that $A > \overline{\theta} \geq \underline{\theta}$.

variables verifiable is prohibitively high whereas the shareholders can still find it worthwhile to pay that cost for a single variable. Differences in costs and accuracy of the monitoring instrument determines shareholders' choice.

[9] Our focus on an incomplete contracting framework where relative performance evaluations are unenforceable can be justified under some natural circumstances. First, as showed by Martimort and Dequiedt (2006), lack of transparency and opportunistic behavior on the principals' side may prevent relative performance contracts to achieve full rent extraction. Second, in adverse selection problems relative performance contracts may loose much of their bite to the extent that they encourage agents to coordinate at the revelation stage. In particular, Tangeras (2002) analyzes the additional insights that arise when regulated firms are able to coordinate their actions explicitly and shows that the value of yardstick competition becomes negligible as the firms' private cost information becomes perfectly correlated (see also Laffont and Martimort, 2000, Sappington, 2002, and Armstrong and Sappington, 2005). Finally, as argued in Martimort (1996), these contacting practices may be condemned for antitrust reasons.

4 The Complete Information Benchmark

Under complete information cost- and profit-based contracts are outcome and payoff equivalent. In this case it is easy to verify that managers get no rents and that the complete information Cournot outcome obtains irrespective of the chosen screening instrument:

$$q_i(\theta) = e_i(\theta) = q^*(\theta) = \frac{A-\theta}{1+\sigma}, \quad \text{for each } \theta \text{ and } i = 1, 2.$$

Moreover, it is important to observe that, in this context, intensified competitive pressure stifles managerial effort. Even if there is no X-inefficiency, that is effort is chosen according to the efficient rule $q^*(\theta) = \psi'(e^*(\theta))$, increasing product market competition spurs organizational slack: When products become closer substitutes, firms scale back their production levels as a response to lower prices, this determines in turn a reduction of effort since production technologies display complementarities between effort and sales: a scale effect.

5 Asymmetric Information

We now turn to the asymmetric information framework. Two main sources of inefficiency are at play in this case. First, managers' private information forces shareholders to give up information rents in order to induce truthful information revelation. Second, since these rents are costly, the market allocation needs to be distorted away from its complete information level. The key point of the section is to show that in the profit-target regime shareholders are able to exploit an indirect and imperfect form of relative performance that produces an efficiency gain relative to cost-target contracts. More specifically, rewarding managers on the basis of observed profits relaxes incentive constraints relative to cost-target contracts because it makes the information rent of each manager (implicitly) contingent on the quantity chosen by his competitor. As we will show, in this regime the inefficiency arising in a standard adverse selection model, associated to managers' informational monopoly power, is mitigated by an horizontal externality between the competing principals. In equilibrium, this horizontal externality reinforces shareholders' control on managers and therefore improves upon X-efficiency. Moreover, since this "efficiency-enhancing" effect tightens as products become closer substitutes, it also leads to obtain an inverted-U shaped relationship between managerial effort and competition.

5.1 Cost-Target Regime

First, we consider the regime where both principals can only enforce cost-target contracts. An incentive feasible allocation has to both induce managers to accept the contract, which amounts to satisfy a pair of participation constraints, PC, and elicit truthful information revelation, that will be ensured by imposing two incentive compatibility constraints, IC.

Let $\Delta\theta = \overline{\theta} - \underline{\theta}$, standard manipulations allow us to obtain (with obvious notation) the relevant participation and incentive constraints:[10]

$$(\overline{PC}) \quad \overline{U}_i \geq 0,$$

$$(\underline{IC}) \quad \underline{U}_i \geq \overline{U}_i + \psi(\overline{e_i}) - \psi(\overline{e_i} - \Delta\theta).$$

From the above incentive constraint one can easily verify that, when marginal costs are used as screening device, product market competition does not have any direct effect on the firms' internal agency conflict.[11] After a standard change of variables, firm i shareholders' optimization problem becomes formally equivalent to the one studied in the regulation model by Laffont and Tirole (1986) where there is one single principal-agent hierarchy:

$$(\mathcal{P}_i^c) \ : \ \begin{cases} \max\limits_{\{(e_i(.),q_i(.),U_i(.))\}_{\theta\in\Theta}} \mathbb{E}_\theta \left[p_i(q_i(\theta), q_j(\theta))q_i(\theta) - C(q_i(\theta), e_i(\theta), \theta) - \psi(e_i(\theta)) - U_i(\theta) \right] \\ \text{s. t.} \ \ (\overline{PC})\text{-}(\underline{IC}). \end{cases}$$

Assuming interior solutions, the symmetric equilibrium allocation $\mathcal{C}^c \equiv \{q^c(\theta), e^c(\theta), w^c(\theta)\}_{\theta\in\Theta}$ solves the following first-order necessary conditions for optimality:

$$A - (2+\sigma)\underline{q}^c = \underline{\theta} - \underline{e}^c, \tag{1}$$

$$\underline{q}^c - \psi'(\underline{e}^c) = 0, \tag{2}$$

$$A - (2+\sigma)\overline{q}^c = \overline{\theta} - \overline{e}^c, \tag{3}$$

$$\overline{q}^c - \psi'(\overline{e}^c) = \frac{\nu}{1-\nu} \cdot \left(\psi'(\overline{e}^c) - \psi'(\overline{e}^c - \Delta\theta)\right), \tag{4}$$

[10] This is standard in adverse selection models and will not be showed.

[11] Bertoletti and Poletti (1997) also pointed this out. In criticizing Martin (1993) they observe that his results do not rely on a *genuine* effect of market competition on incentives, but are rather driven by a scale effect at play through marginal revenues.

and the wage *identification* conditions

$$\underline{w}^c = \psi(\underline{e}^c) + \psi(\overline{e}^c) - \psi(\overline{e}^c - \Delta\theta), \tag{5}$$

$$\overline{w}^c = \psi(\overline{e}^c). \tag{6}$$

Equations (1) and (2) are the first-order conditions with respect to $\underline{q}_i$ and $\underline{e}_i$: (1) implies that, in the low-cost realization, marginal revenues must be equal to marginal costs; while (2) implies that effort is set according to the efficient rule. Equation (4) is the first-order condition with respect to $\overline{e}_i$. It expresses a second-best rule in that the effort decision must now take into account the fact that information rents are increasing in $\overline{e}_i$. This leads to distort downward allocative efficiency for rent extraction reasons. Everything works then as if the true marginal cost parameter $\overline{\theta}$ were replaced by its virtual value

$$\overline{\theta}^c = \overline{\theta} + \frac{\nu}{1-\nu}\Delta\theta,$$

which accounts for the shadow cost of information rents. Finally, equation (3) is the first-order condition with respect to $\overline{q}_i$. Notice that, for any given effort level, this condition implies that sales are chosen efficiently also in the high-cost state. This is reminiscent of the "dichotomy" result obtained by Laffont and Tirole (1993, Chapter 3) in a regulatory framework: Since only marginal costs are used as screening device, the sales level can be set according to the efficient rule. Finally, equations (5) and (6) just define the equilibrium wages received by each manager. The former equation implies that a low-cost manager receives a wage that covers his effort disutility and also rewards him for truthful information revelation; the latter simply reflects the fact that the high-cost manager gets zero rents so that his wage only covers the disutility of effort.

Solving equations (1)-(4) one gets the complete information allocation in the low-cost state, that is $\underline{e}^c = \underline{q}^c = \underline{e}^*$, and underproduction in the high-cost state, that is:

$$\overline{e}^c = \overline{e}^* - \frac{\nu}{1-\nu} \cdot \frac{2+\sigma}{1+\sigma}\Delta\theta, \tag{7}$$

and,

$$\overline{q}^c = \overline{q}^* - \frac{\nu}{1-\nu} \cdot \frac{1}{1+\sigma}\Delta\theta. \tag{8}$$

It should be noticed that, even though sales are not used as a screening device, their level falls below the complete information benchmark because the contracted effort must be downward distorted for rent extraction reasons.

5.2 Profit-Target Regime

We now consider the case where both principals use average profits, rather than marginal costs, as screening device. As before, an incentive feasible allocation must satisfy incentive compatibility and participation constraints for all managers' types. Standard manipulations then allow to rewrite the relevant constraints as:[12]

$$(\overline{PC}) \quad \overline{U}_i \geq 0,$$

$$(\underline{IC}) \quad \underline{U}_i \geq \overline{U}_i + \psi(\overline{e_i}) - \psi(\overline{e_i} - \Delta\theta + \sigma(\underline{q}_j - \overline{q}_j)).$$

In this case the degree of product market competition directly affects the relevant incentive constraint through the additional term $\sigma(\underline{q}_j - \overline{q}_j)$. This term formally captures a contractual externality between the competing firms — a so called competing-contracts effect (Martimort, 1996) — which will play a crucial role in our analysis. The key idea is that intensified product market competition, as reflected by larger values of σ, and greater responsiveness of the rival firm to cost fluctuations, as measured by $\underline{q}_j - \overline{q}_j$, weaken (resp. strengthen) the incentive that a low-cost type (resp. high-) has to overstate (resp. understate) his true type. To see this point more clearly, observe that two contrasting effects now shape the managers' incentive to mimic at the revelation stage:

(i) A low-cost manager may overstate his type to convince shareholders that profits are low due to an unfavorable draw rather than to his low effort: a standard (effort) cost-saving effect, which is formally captured by $\Delta\theta$.

(ii) Since types are perfectly correlated, however, by overstating his type a low-cost manager induces his shareholders to believe that the rival firm faces high costs as well and thus produces less. Having assumed Nash behavior at the revelation stage,[13] this manager knows that his rival will "tell the truth" and will thus produce more than what expected by his shareholders. Hence, in order to avoid a punishment by his shareholders, the mimicking manager is forced to increase his effort so as to compensate the unexpected reduction in profits driven by his rival's overproduction. Clearly, this makes information revelation less costly relative to the case of cost-target: an indirect efficiency-enhancing effect driven by competing-contracts.[14]

[12] In the Appendix we show that the incentive constraint of a high-cost manager holds in a PBE equilibrium where these constraints are satisfied with equality.

[13] When a manager reports his message about the state of nature, he takes as certain the fact that his rival truthfully reports the state of nature. This implicitly implies a noncooperative behavior at the revelation stage.

[14] The same kind of logic explains why this indirect effect strengthens the incentive constraint of a high-cost type.

After a standard change of variables, principal i's optimization problem can be written as:

$$(\mathcal{P}_i^p) \ : \ \begin{cases} \max\limits_{\{(e_i(.),q_i(.),U_i(.))\}_{\theta\in\Theta}} \mathbb{E}_\theta \left[p_i(q_i(\theta), q_j(\theta))q_i(\theta) - C(q_i(\theta), e_i(\theta), \theta) - \psi(e_i(\theta)) - U_i(\theta)\right] \\ \text{s. t.} \ \ (\overline{PC})\text{-}(\underline{IC}). \end{cases}$$

Assuming interior solutions, it can be easily showed that the symmetric (market-) equilibrium allocation $\mathcal{C}^p \equiv \{q^p(\theta), e^p(\theta), w^p(\theta)\}_{\theta\in\Theta}$ solves the first-order conditions:

$$A - (2+\sigma)\underline{q}^p = \underline{\theta} - \underline{e}^p, \tag{9}$$

$$\underline{q}^p - \psi'(\underline{e}^p) = 0, \tag{10}$$

$$A - (2+\sigma)\overline{q}^p = \overline{\theta} - \overline{e}^p, \tag{11}$$

$$\overline{q}^p - \psi'(\overline{e}^p) = \frac{\nu}{1-\nu} \cdot (\psi'(\overline{e}^p) - \psi'(\overline{e}^p - \Delta\theta + \sigma(\underline{q}^p - \overline{q}^p))), \tag{12}$$

and the wage *identification* conditions

$$\underline{w}^p = \psi(\underline{e}^p) + \psi(\overline{e}^p) - \psi(\overline{e}^p - \Delta\theta + \sigma(\underline{q}^p - \overline{q}^p)), \tag{13}$$

$$\overline{w}^c = \psi(\overline{e}^p). \tag{14}$$

Equations (9) and (10) are the first-order conditions with respect to $\underline{q}_i$ and $\underline{e}_i$. As in the previous regime, they imply that marginal revenues must be equated to marginal costs at the optimum, and that low-cost types exert the complete information effort level. Equations (11) and (12) are the first-order conditions with respect to $\overline{q}_i$ and $\overline{e}_i$. The dichotomy result holds also in this regime, therefore the sales level is chosen according to the efficient rule, while effort must be set below the complete information level for rent extraction reasons. However, it is important to observe that now the virtual marginal cost value

$$\overline{\theta}^p = \overline{\theta} + \frac{\nu}{1-\nu} \cdot (\Delta\theta - \sigma(\underline{q}^* - \overline{q}^p)) = \overline{\theta} + \frac{\nu}{1-\nu+\sigma}\Delta\theta < \overline{\theta}^c$$

takes also into account the competing-contracts effect.

Once more, equations (13) and (14) define equilibrium wages in the low- and high- cost states, respectively. The wage paid to a low-cost manager covers his effort disutility and also rewards him for truthful information revelation; by contrast, that paid to the high-cost manager only covers his effort disutility.

Solving equations (9)-(12) one gets $\underline{q}^p = \underline{e}^p = \underline{e}^*$,

$$\overline{e}^p = \overline{e}^* - \frac{\nu}{1-\nu+\sigma} \cdot \frac{2+\sigma}{1+\sigma}\Delta\theta, \tag{15}$$

and,

$$\overline{q}^p = \overline{q}^* - \frac{\nu}{1-\nu+\sigma} \cdot \frac{1}{1+\sigma}\Delta\theta. \tag{16}$$

Clearly, also in this regime optimality requires no distortion at the top and downward distortion at the bottom. Moreover, as before, even though sales are not used as a screening device, in the high-cost state their level falls below the complete information value because the contracted effort is downward distorted.[15]

5.3 Product Market Competition and Organizational Slack

In this section we illustrate the equilibrium features of the two contractual regimes analyzed above. Our objective is twofold. First, we show that profit-target contracts enhance productive as well as allocative efficiency relative to cost-based ones. Second, we perform a comparative statics exercise showing that, in contrast to the case of cost-based contracts, an inverted-U shaped relationship between managerial effort and competition may obtain when contracts are based on realized profits.

To begin with, in the next lemma we show how efforts and outputs are ordered under both contractual regimes. Clearly, in the low-cost state both managers produce at the complete information level irrespective of the contractual regime. In the high-cost state, however, the different impact on rents of the two screening instruments determines an important difference.

Lemma 1 *The symmetric (market-) equilibrium allocations satisfy the following properties:* $\overline{e}^p \geq \overline{e}^c$ *and* $\overline{q}^p \geq \overline{q}^c$*, with equalities holding only at* $\sigma = 0$*.*

This result implies that profit-target contracts enhance productive as well as allocative efficiency relative to cost-target contracts. This is so because when profits are used as screening device information rents depend (negatively) on the rivals' market share. As explained before, this weakens the incentive for efficient managers to mimic inefficient ones, thereby mitigating the rent-extraction efficiency trade-off and, in turn, managerial slack.

We now turn to study the comparative statics properties of effort with respect to product market competition. Of course, under both regimes more intense competition unambiguously

[15] A formal difference with Martimort (1996) is that in his framework with pure adverse selection sales need to be distorted for rent extraction reasons, in our framework instead only effort is distorted as implied by the dichotomy result.

stifles managerial effort in the low-cost state since effort is set at its complete information level. However, in the high-cost state results may change depending on the chosen screening instrument.

The next lemma shows that, as pointed out in Martin (1993), also in our framework there is a positive relationship between competition and X-inefficiency holds whenever executive compensations are based on costs.

Lemma 2 *Under cost-based contracts more intense product market competition unambiguously stifles managerial effort.*

The intuition for this result rests upon the idea that in the cost-target regime incentive constraints are not (directly) affected by the degree of products' substitutability and that profits display complementarities between sales and effort. Greater competition leads to lower profits, hence the marginal benefit of reducing costs (the value of managerial effort) falls as well: a scale effect à la Martin (1993).

The scale effect is also at play under profit-based contracts, even though in this regime a counterbalancing *agency effect*, driven by competing-contracts, might lead product market competition to have a positive impact on the effort exerted by high-cost managers. In order to assess the magnitude of each of these effects, we compute the derivative of $\overline{e}^p(\sigma)$ with respect to σ. Simple algebra (see the Appendix) allows to obtain:

$$\frac{\partial \overline{e}^p(\sigma)}{\partial \sigma} = -\underbrace{\frac{A-\underline{\theta}}{(1+\sigma)^2}}_{\textbf{Scale Effect}} + \underbrace{\frac{1+\nu}{(1-\nu+\sigma)^2}\Delta\theta}_{\textbf{Agency Effect}}. \tag{17}$$

By inspecting expression (17) one can see that its sign is determined by two terms: The first negative addendum captures the scale effect, whereas the second positive term measures the agency effect. The overall effect will be determined by the following parameters: (i) the intensity of product market competition, as measured by the degree of products' substitutability; (ii) the probability of low-cost realizations; (iii) an index of the market profitability; and (iv) the measure of the severity of the adverse selection problem.

Before stating the conditions under which an inverted-U shaped relationship between competition and managerial effort obtains, it is useful to clearly define the space of parameters where the equilibrium with profit-target entails no shut-down.

Denote $\gamma = (A-\underline{\theta})/\Delta\theta > 1$ and, for any given γ, let $\nu^*(\gamma) = (\gamma-1)/(\gamma+1)$ with $\nu^* < 1$.

Proposition 1 $\overline{e}^p(\sigma) > 0$ *and* $\overline{q}^p(\sigma) > 0$ *for all* σ *if and only if* $\nu < \nu^*(\gamma)$.

Thus effort and quantity are strictly positive if the probability of the low-cost state is not large enough. Intuitively, in our linear framework principals' marginal return at zero output is not infinite, hence principals may want to implement an excessively large distortion on the high-cost type whenever this state is sufficiently unlikely.

We now turn to show the conditions under which the inverted-U shaped relationship exists. In doing so we will take into account the restriction implied by Proposition 1.

For any $\gamma > 1$ let $\nu^{**}(\gamma) = \frac{1}{\gamma}\left(\frac{1}{2} + \gamma - \frac{1}{2}\sqrt{8\gamma + 1}\right)$,

Proposition 2 *The following properties hold:*

(i) The function $\overline{e}^p(\sigma)$ *is inverted-U shaped in the region of parameters defined by the following inequality:*

$$\gamma < \frac{1+\nu}{(1-\nu)^2}, \tag{18}$$

and is decreasing otherwise.

(ii) The subset of parameters where $\overline{e}^p(\sigma)$ *is inverted-U shaped and no shut down emerges is non empty for* $\nu \in (\nu^{**}(\gamma), \nu^{*}(\gamma))$*, where* $\nu^{**}(\gamma) \leq \nu^{*}(\gamma)$ *for all* $\gamma > 1$ *with equality holding only at* $\gamma = +\infty$.

This result shows the existence of an inverted-U shaped relationship between product market competition and effort. It implies that the agency effect is more pronounced for low levels of products' substitutability, while it is offset by the scale effect when products become closer substitutes. More specifically, when the size of informational problems, measured by $\Delta\theta$, is large relative to a measure of profit margins, measured by $A - \underline{\theta}$, i.e., γ is small, and products substitutability is sufficiently small, the effect of intensified competition on informational rents — and thus on effort — more than compensates the price reduction effect. This is because when competition is weak, the level of information rents is close to that of an isolated principal-agent relationship. In this case, these agency costs are so large that even small variations of products substitutability have a huge impact in relaxing incentive constraints through competing-contracts. Clearly, this effect becomes less pronounced when competition is stronger because it reduces the rival's responsiveness to cost fluctuations, thereby weakening the relative performance role of the competing-contracts effect. Intuitively, this explains why the scale effect becomes dominant when competition is intense enough, thus determining the inverted-U shaped result.[16] It should be noticed that when information problems are small relative to profit margins, the allocations obtained under both regimes

[16] It is worth observing that intensified competition may stifles marginal costs even under complete information when the disutility of effort is per unit of sales, $\psi(e, q)$. For example, one can easily check that this is the case whenever such a function displays strong complementarities between effort and sales, that is if $\psi_{eq}(.)$ is large enough.

are nearly equal to their complete information level. In this case the scale effect will dominate so as to drive a positive relationship between product market competition and organizational slack, as under complete information.

Finally, since we show in the Appendix that $\nu^{**}(\gamma) \geq \nu^{*}(\gamma)$ for all γ, it is also important to emphasize that the region of parameters where the effort is inverted-U shaped and $\mathcal{P}_i^p$ has an interior solution is a non empty set. Moreover, simple comparative statics on (18) also implies that in this set the inverted-U shaped result holds more frequently when production technologies are stochastically more efficient, that is for larger values of ν. Intuitively, when favorable realizations of the production technology are more likely, equilibrium contracts command a higher distortion because shareholders care less about high-cost states. This, in turn, tightens the role of the competing-contracts effect in shaping incentives and reinforces the agency effect. Interestingly, this result is in line with the empirical evidence documented by Aghion et al. (2005), showing a stronger evidence of the inverted-U shaped relationship in industries with a higher innovation rate, which in our framework may be measured by the probability of low-cost shocks, i.e., $\Pr(\widetilde{\theta} = \underline{\theta}) = \nu$.

6 Robustness: Endogenous Instruments

So far, the analysis has been developed by assuming exogenous contractual regimes. We have showed that, in contrast to cost-target contracts, introducing reward schemes based on profits into a simple managerial framework à la Martin (1993) with perfect correlation between managers' types, delivers interesting comparative statics results that generate predictions in line with the empirical evidence presented in Aghion et al. (2005).

However, a natural question arises as to whether conditioning managerial compensations on profits is more reasonable than simply assuming cost-target rules. Addressing this robustness issue is important in order to contrast our analysis with previous literature that has typically assumed cost-target contracts. This is done by studying a slightly more complex game where the choice of the screening instruments is endogenous. The main formal difference with the previous analysis is that, in this section, the strategy of each principal also specifies the type of screening instrument in addition to an allocation proposal.

We assume that everything happens at the same stage: After uncertainty is realized, shareholders simultaneously and secretly decide which type of screening instrument to adopt (cost or

In light of this consideration, our analysis adds to previous literature in that it makes clear that similar results can be driven by information asymmetries once contracts are based on profits (rather than on costs), even if such complementarity is not due to technological factors.

profit) and, accordingly, make a take-it or leave-it offer to their managers.[17] The game then unfolds exactly as before. The solution concept remains PBE and we shall look for symmetric equilibrium of this new game with contract choices.[18] Finally, for the sake of tractability, we restrict attention to cases where effort, quantities and marginal costs are (strictly) positive. To this end, throughout we will assume that $\Delta\theta$ is small. This assumption, together with $\nu > 0$ and $\sigma > 0$ rules out the possibility of solutions with shut-down.[19]

Proposition 3 *Assume $\Delta\theta$ is small enough, then the game of contractual choices with endogenous screening instruments displays the following properties:*

(i) A symmetric PBE with profit-target always exists for all pairs $(\sigma, \nu) \in (0, 1]^2$;

(ii) A symmetric PBE with cost-target contracts exists if and only if $(\nu, \sigma) \in \Gamma$, where

$$\Gamma \equiv \left\{(\nu, \sigma) \in (0, 1]^2 : \nu > 1/2,\ (1 - \nu)/\nu \leq \sigma \leq 1\right\}.$$

This result shows that profit-target contracts are always an equilibrium of the game of contractual choices, whereas cost-target contracts may only be if product market competition is fierce enough and low-cost states are relatively more likely than high-cost ones. The intuition for this result is again driven by the different impact that the two kinds of screening instruments have on managers' information rents.

Consider an equilibrium candidate where both firms are ruled by a profit-target mechanism, the key question is then whether there exists a profitable deviation to a cost-target contract. Assume, without loss of generality, that principal i considers deviating while his competitor sticks with his

[17] We explicitly rule out public contracts because this seems inappropriate in the framework at hand. Indeed, 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 actual rules by which these compensations are calculated may be a very difficult task, for instance because of secret renegotiation.

[18] Although the question of whether there are asymmetric equilibria is an interesting theoretical issue per se, it is beyond the scope of the present section.

[19] Assuming $\Delta\theta$ small allows us to use first-order Taylor expansions to derive expected profits, see the Appendix. Restricting our focus to cases where the size of asymmetric information $\Delta\theta$ is small, is rather standard in complex adverse selection models, see for instance Martimort and Stole (2007), Martimort and Moreira (2007) and Martimort and Piccolo (2007-19). In the real world this assumption may well capture the case of mature industries where uncertainty about production technologies is small or instances where the information gap between ownership and management is not too large. In the long run, indeed, shareholders may successfully improve their ability to gather information about production technologies so as to reduce the informative advantage of their managers. Finally, it is also important to observe that $\Delta\theta$ small is not in contrast with the inverted-U shaped result. Indeed, only when $\Delta\theta = 0$ then $\gamma \to +\infty$ and the set $(\nu^{**}(+\infty), \nu^{*}(+\infty))$ becomes a singleton, but for all $\Delta\theta > 0$ this interval is non empty.

equilibrium strategy. Two effects are simultaneously at play once principal i moves from a profit- to a cost-target contract:

(i) First, in order to satisfy incentive constraints this kind of deviation forces manager i to behave less aggressively in the marketplace because the rent extraction efficiency trade-off becomes more severe under cost-target: a negative strategic effect.

(ii) Second, agency costs are higher under the cost-target regime because the competing-contracts effect is absent in this case: an agency cost.

Both these effects point in the direction of decreasing principal i's profits after a deviation, therefore a PBE with profit-target contracts exists in the whole parameters' space.

The same kind of logic allows us to explain why cost-target contracts can be part of a PBE in the subset of parameters where both ν and σ are large. Consider an equilibrium candidate where both firms are ruled by a cost-target contract. Once more, we have to verify whether there is a profitable deviation to a profit-target contract and, even more importantly, if this possibility depends upon the strength of product market competition and the relative likelihood of the high-cost state. A key point to observe in this regard is that for all $(\nu, \sigma) \in \Gamma$ the off-equilibrium incentive constraint (i.e., that faced by principal i when he deviates to profit-target given that his rival sticks with the equilibrium candidate $\mathcal{C}^c$) of the low-cost manager i can be rewritten as:

$$\underline{U}_i \geq \overline{U}_i + \psi(\overline{e}_i) - \psi\left(\overline{e}_i - \frac{1-(1+\sigma)\nu}{(1-\nu)(1+\sigma)}\Delta\theta\right).$$

Straightforward manipulations then imply that the term $(1-(1+\sigma)\nu)/(1-\nu)(1+\sigma)$ is negative for all $(\nu, \sigma) \in \Gamma$. This implies that in that subset of parameters one has

$$\psi(\overline{e}_i) < \psi\left(\overline{e}_i - \frac{1-(1+\sigma)\nu}{(1-\nu)(1+\sigma)}\Delta\theta\right).$$

In this case one can verify (see the Appendix) that, off-equilibrium, the incentive constraint of a high-cost manager and the participation constraint of a low-cost one must bind, so that[20]

$$\overline{U}_i = \psi(\underline{e}_i) - \psi\left(\underline{e}_i + \frac{1-(1+\sigma)\nu}{(1-\nu)(1+\sigma)}\Delta\theta\right).$$

The optimal contract must then feature countervailing incentives: The quantity-effort pair must be upward distorted (relative to the complete information benchmark) when marginal costs are high[21] and downward distorted when these are low. Two contrasting effects are then at play

[20] See, for instance, Laffont and Martimort (2002, Ch. 3).

[21] Notice that this happens because the competing firm sticks with the equilibrium behavior entailing distortion

once principal i deviates from a cost-target to a profit-target contract:

(i) First, deviating to profit-target contract commands a weaker competitive stance in the low-cost state (which is relatively more likely than a high-cost one): a negative strategic effect.

(ii) Second, it also leads to give up rents only in the high-cost state which is less likely: a positive rent-saving effect.

It then follows that when the efficient cost state is relatively more likely and information rents are bounded by $\Delta\theta$ small, a deviation to profit-target is not profitable if competition is fierce enough. In this case the negative strategic effect outweighs the rent-saving one. Intuitively, this is because the cost of being less aggressive on the market more than compensates the expected reduction of rents associated to a deviation to profit target.

Although Proposition 3 supports the view that one should observe more often profit-target contracts in real markets, an equilibrium selection issue still remains open in the parameters' subspace Γ. Which equilibrium should be expected in this region? In order to address this multiplicity problem in the reminder of the section we propose three simple selection criteria.

The next proposition provides a simple equilibrium refinement, which allows to show that shareholders prefer a PBE with profit-target contracts to one with cost-target.

Proposition 4 *Assume that $\Delta\theta$ is small enough, then shareholders are better-off under a profit-target regime relative to a cost-target regime; they are indifferent only for $\sigma = 0$.*

When shareholders jointly move from an equilibrium with profit-target contracts to one with cost-target, two effects determine the change in their profits. On the one hand, information rents increase because the competing-contracts effect is absent under cost-target contracts. On the other hand, revenues decrease because, as shown in Lemma 1, these contracts also command a higher distortion of effort and sales relative to profit-target. Therefore, the equilibrium with profit-target contracts Pareto dominates that with cost-target contracts.

The next proposition shows that the same kind of conclusion holds under risk dominance. Before stating the result, it is worthwhile explaining what kind of exercise we will perform here. Indeed, while the risk dominance refinement concept is straightforward in two-players games, its definition needs more carefulness in games of competing hierarchies.

In the analysis we shall exploit symmetry of the competing hierarchies and assume that the rule according to which an equilibrium is selected is the following: each principal chooses the best contractual offer $\mathcal{C}_i \in \{\mathcal{C}^p, \mathcal{C}^c\}$ under the belief that his rival mixes between these two offers with

at the bottom. Therefore, in the optimal deviation the manager i must produce above the complete information level in the state $\overline{\theta}$.

equal probability.[22] As for the agents', instead, we shall impose again a *passive beliefs* restriction. This means that, given any offer $\mathcal{C}_i$ made by principal i to his agent, this latter believes that principal j will offer the same contract with certainty.[23]

Proposition 5 *Assume that $\Delta\theta$ is small enough, then for any pair $(\nu, \sigma) \in \Gamma$ the PBE with profit-target contracts "risk dominates" that with cost-target contracts.*

Under the hypothesis of managers' passive beliefs the economic intuition of this result rests again on the idea that a principal offering the allocation obtained under the profit-target regime behaves more aggressively at the market stage relative to one offering the cost-target allocation, and also bears lower agency costs.

Finally, in the next proposition we show that the PBE with reward schemes based on profits also survives to a refinement concept based on constrained joint-profit maximization, that is when the selected equilibrium offer is that which maximizes the expected profit of the coalition formed by the shareholders and the manager. This criterion can be justified by long-run considerations. Indeed, one should not expect organizations which do not maximize ex-ante joint-profit to survive in the long-run if we were modelling explicitly entry.

Proposition 6 *Assume that $\Delta\theta$ is small enough, then the coalition formed by shareholders and managers is better-off under a profit-target regime relative to a cost-target one.*

In the joint-profit case agency costs do not influence the choice of the equilibrium offer because utilities are transferable, hence the economic intuition for this result is simply that under the profit-target allocation each firm is more aggressive at market stage relative to the cost-target allocation.

7 Concluding Remarks

By introducing profit-target contracts in a framework à la Martin (1993) with common components in managers' private information the paper offers three novel insights to the body of literature on competition and incentives. First, we have identified a new agency channel through which competition affects managers' performance when they are rewarded on the basis of realized profits. Second, we have shown that this agency effect delivers an inverted-U shaped relationship between

[22] This is standard in symmetric games (see for instance Fudenberg and Tirole, 1991, Ch. 1).

[23] This may well be the case when shareholders are able to observe some private signals about the strategy of their rivals that cannot be observed by the managers. In the real-world this could be due to unmodeled forms of pre-play communication between shareholders.

competition and organizational slack which is consistent with the most recent empirical evidence. Third, our results suggest that a proper test of the impact of competition on managerial incentives should control — whenever possible — for: (i) the type of reward schemes implemented in managerial firms, (ii) the size of asymmetric information, and (iii) the industrywide probability of favorable technological shocks. The relevance of these results is twofold. On the one hand, they provide new insights to the theoretical analysis of models of competing hierarchies under incomplete information by unveiling that the link between competition and organizational slack may be non-monotonic whenever contracts are based on profits. On the other hand, the finding of an inverted-U shaped relationship between competition and managerial effort brings the theory closer to the empirical evidence.

Two main simplifying assumptions have been imposed. First, the analysis has been carried out under the assumption of discrete types. Second, we assumed perfect (positive) correlation between managers' types. The results of the paper can be generalized by relaxing both these assumptions. Introducing a continuum of types does not change qualitatively our conclusions. In fact, the competing-contracts effect would still be at play with a compact support of types. This can be readily shown by adapting the analysis performed in Martimort (1996) to our framework with the added moral hazard component. Moreover, introducing correlated types would not add new insights to our findings. Results would remain qualitatively the same in this more complex environment, provided that correlation between managers' types is positive and sufficiently large. The reason is that, when types are correlated, a sort of competing-contracts effect is still at play in relaxing incentive constraints in the profit-target regime. The proof of this argument is provided in Gal-Or (1999) who shows that, with correlated types, a *steepness effect* (similar to Martimort's competing contracts) relaxes incentive constraints in games of competing hierarchies.

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8 Appendix

Incentive Feasible Allocations under Profit-Target

Let $\overline{IC}$ be

$$\overline{U}_i \geq \underline{U}_i + \psi(\underline{e}_i) - \psi(\underline{e}_i + \Delta\theta - \sigma(\underline{q}_j - \overline{q}_j)).$$

Adding up $\underline{IC}$ and $\overline{IC}$ we get:

$$\Psi\left(\left(q_i\left(\theta\right), \tau_i\left(\theta\right)\right)_{\theta\in\Theta}, \left(q_j\left(\theta\right)\right)_{\theta\in\Theta}\right) \equiv \int_{\overline{\tau}_i+\overline{q}_i}^{\underline{\tau}_i+\underline{q}_i}\int_{\underline{\theta}+\sigma\underline{q}_j}^{\overline{\theta}+\sigma\overline{q}_j}\psi''(t+s-A)dtds \geq 0,$$

which yields a *modified* monotonicity condition

$$\Delta\theta \geq \sigma(\underline{q}_j - \overline{q}_j) \text{ (resp. } < \text{) and } \underline{\tau}_i + \underline{q}_i \geq \overline{\tau}_i + \overline{q}_i \text{ (resp. } < \text{)}. \tag{19}$$

Then, it is easy to verify that if an allocation satisfies one of the two incentive compatibility constraints with equality and (19), also the remaining incentive constraint must be satisfied.

By conjecturing that $\Delta\theta \geq \sigma(\underline{q}_j - \overline{q}_j)$ at the equilibrium, it is easy to show that $\overline{PC}$ and $\underline{IC}$ together imply $\underline{PC}$. Principal i thus chooses a mechanism so to maximize the following (relaxed) maximization program neglecting $\overline{IC}$:

$$\begin{array}{l} \max\limits_{\left\{(\overline{e}_i,\overline{q}_i),(\underline{e}_i,\underline{q}_i,\underline{U}_i)\right\}} \mathbb{E}_\theta[p(q_i\left(\theta\right), q_j(\theta))q_i\left(\theta\right) - C(q_i(\theta), e_i(\theta), \theta) - \psi\left(e_i\left(\theta\right)\right)] - \nu\underline{U}_i \\ \text{s.t. } \underline{U}_i = \psi(\overline{e}_i) - \psi(\overline{e}_i - \Delta\theta + \sigma(\underline{q}_j - \overline{q}_j)), \end{array},$$

The solution of this program yields immediately the first-order conditions (9)-(12). Finally, we show that $\mathcal{P}_i^p$ is well behaved at the equilibrium allocation $\mathcal{C}^p$. First, observe that from linearity of $p_i(.)$ and convexity of $\psi(.)$ first-order conditions (9)-(12) are necessary and sufficient for a unique optimum. Moreover, as explained above, to show that $\overline{IC}$ also holds, it is enough checking that the pair $(\underline{q}^*, \overline{q}^p)$ satisfies (19). Now, since $\underline{q}^* > \overline{q}^p$, equation (19) holds if $\Delta\theta \geq \sigma(\underline{q}^* - \overline{q}^p)$ for all σ. Simple algebra then allows to show that:

$$\Delta\theta - \sigma(\underline{q}^* - \overline{q}^p) = \frac{1-\nu}{1-\nu+\sigma}\Delta\theta \geq 0,$$

which concludes the characterization. □

Proof of Lemma 1

Showing that $\underline{e}^p = \underline{e}^c = \underline{e}^*$ is straightforward. Moreover, since we have assumed internal solutions, by using (7), (8), (15) and (16) simple algebraic manipulations yield:

$$\frac{1-\nu}{\nu}\left(\overline{q}^p - \overline{q}^c\right) = \frac{\sigma\Delta\theta}{(1-\nu+\sigma)(1+\sigma)} \geq 0, \tag{20}$$

$$\frac{1-\nu}{\nu}\left(\overline{e}^p - \overline{e}^c\right) = \frac{\sigma(2+\sigma)\Delta\theta}{(1-\nu+\sigma)(1+\sigma)} \geq 0, \tag{21}$$

with equality holding at $\sigma = 0$. This immediately proves the result. □

Proof of Proposition 1

Observe that the first-order condition (12) implies $\overline{e}^p(\sigma,\nu) > \overline{q}^p(\sigma,\nu)$ for all $(\sigma,\nu) \in [0,1]^2$. Hence, in order for $\mathcal{P}_i^p$ to have an interior solution it suffices to impose $\overline{e}^p(\sigma,\nu) > 0$, that is :

$$\frac{A-\overline{\theta}}{\Delta\theta} > \frac{\nu(2+\sigma)}{1-\nu+\sigma} \text{ for all } \sigma,$$

substituting for $\overline{\theta} = \Delta\theta + \underline{\theta}$ into the above equation one has:

$$\gamma > \frac{(1+\nu)(1+\sigma)}{1-\nu+\sigma} \text{ for all } \sigma.$$

Since the right-hand side of the above inequality is decreasing in σ for all $\nu \in (0,1]$, that is

$$\frac{\partial}{\partial\sigma}\cdot\frac{(1+\nu)(1+\sigma)}{1-\nu+\sigma} = -\frac{(1+\nu)\nu}{(1-\nu+\sigma)^2},$$

one has that $\overline{e}^p(\sigma,\nu) > 0$ for every (σ,ν) whenever the following condition holds:

$$\gamma > \lim_{\sigma\to 0}\frac{(1+\nu)(1+\sigma)}{1-\nu+\sigma} = \frac{1+\nu}{1-\nu},$$

so that $\overline{e}^p(\sigma,\nu) > 0$ implies $\gamma > (1+\nu)/(1-\nu)$. Hence $\overline{e}^p(\sigma,\nu) > 0$ for all $\sigma \in [0,1]$ if and only if $\nu < \nu^*(\gamma) = (\gamma-1)/(\gamma+1)$, where it is trivial to verify that $\nu^*(\gamma) < 1$ since $A > \overline{\theta}$.

Proof of Proposition 2

Using equation (17) one can show that $\partial\overline{e}^p(\sigma)/\partial\sigma$ rewrites as:

$$\frac{\partial\overline{e}^p(\sigma)}{\partial\sigma} = -\frac{A-\overline{\theta}}{(1+\sigma)^2} + \frac{1+\nu}{(1-\nu+\sigma)^2}\cdot\frac{3-\nu+4\sigma+\sigma^2}{(1+\sigma)^2}\Delta\theta,$$

substituting for $\overline{\theta} = \Delta\theta + \underline{\theta}$ into the above equation and rearranging terms we obtain

$$sign\frac{\partial \overline{e}^p(\sigma)}{\partial\sigma} = sign\left(\frac{(1+\nu)(1+\sigma)^2}{(1-\nu+\sigma)^2} - \gamma\right).$$

Now, let $g(\sigma,\nu) = (1+\nu)(1+\sigma)^2/(1-\nu+\sigma)^2$, simple algebra allows to obtain $g(0,\nu) = (1+\nu)/\left(1-\nu\right)^2$, $g(1,\nu) = 4(1+\nu)/(2-\nu)^2$, and

$$\frac{\partial g(\sigma,\nu)}{\partial\sigma} = -\frac{2(1+\sigma)(1+\nu)\nu}{(1-\nu+\sigma)^3} < 0 \text{ for all } \sigma.$$

Then, one can easily verify that $g(0,\nu) > g(1,\nu) > 0$ for all ν. Hence for $\overline{e}^p(\sigma) > 0$ and $\partial\overline{e}^p(\sigma)/\partial\sigma$ to be positive for some σ it must be $\sup_\sigma g(\sigma,\nu) = (1+\nu)/\left(1-\nu\right)^2 > \gamma$ and $\gamma > (1+\nu)/\left(1-\nu\right)$. This immediately implies:

$$\nu \in \left(\frac{1}{\gamma}\left(\frac{1}{2}+\gamma-\frac{1}{2}\sqrt{8\gamma+1}\right), \min\left\{\frac{\gamma-1}{\gamma+1}, \frac{1}{\gamma}\left(\frac{1}{2}+\gamma+\frac{1}{2}\sqrt{8\gamma+1}\right)\right\}\right),$$

where it is easy to show that for all $\gamma > 1$

$$\min\left\{\frac{\gamma-1}{\gamma+1}, \frac{1}{\gamma}\left(\frac{1}{2}+\gamma+\frac{1}{2}\sqrt{8\gamma+1}\right)\right\} = \frac{\gamma-1}{\gamma+1}.$$

Moreover, observe that $\overline{e}^p(\sigma) > 0$ and $\partial\overline{e}^p(\sigma)/\partial\sigma > 0$ for all σ are incompatible. Indeed, this would require $\gamma > (1+\nu)/\left(1-\nu\right)$, so that $\nu < \nu^*\left(\gamma\right)$, and $\inf_\sigma g(\sigma,\nu) = 4(1+\nu)/\left(2-\nu\right)^2 > \gamma$, which implies $\nu > \frac{1}{\gamma}\left(2(1+\gamma) - 2\sqrt{3\gamma+1}\right) = \hat{\nu}\left(\gamma\right)$. But it is easy to show that $\hat{\nu}\left(\gamma\right) > \nu^*\left(\gamma\right)$ for all $\gamma > 1$, so that the set where $\overline{e}^p(\sigma) > 0$ and $\partial\overline{e}^p(\sigma)/\partial\sigma > 0$ for all σ is empty.

Thus if $\nu^{**}\left(\gamma\right) < \nu < \nu^*\left(\gamma\right)$, by continuity, there must exist a threshold $\sigma^*(\nu) \in (0,1)$ such that $\partial\overline{e}^p(\sigma)/\partial\sigma \geq 0$ if (resp. $<$) $\sigma \leq \sigma^*(\nu)$ (resp. $>$). Moreover, if $\gamma \geq g(0,\nu)$, that is if $\nu < \nu^{**}\left(\gamma\right)$, it is immediate to show that $\partial\overline{e}^p(\sigma)/\partial\sigma < 0$. Finally, observe that

$$\nu^*\left(\gamma\right) - \nu^{**}\left(\gamma\right) = \frac{\left(1+\gamma\right)\sqrt{8\gamma+1} - 5\gamma - 1}{2\gamma\left(1+\gamma\right)}$$

is strictly positive for all $1 < \nu < +\infty$ and goes to zero only for $\gamma \to +\infty$. This shows that the inverted-U shaped result is consistent with non-shut down in the non-empty set $\left(\nu^{**}\left(\gamma\right), \nu^*\left(\gamma\right)\right)$ and concludes the proof. □

Proof of Proposition 3

The logic of this proof is (mainly) based upon a revealed preferences argument. Indeed, programs $\mathcal{P}_i^p$ and $\mathcal{P}_i^c$ display the same objective function but different incentive constraints. Hence, if the allocation solving $\mathcal{P}_i^p$ is feasible in $\mathcal{P}_i^c$, strict concavity of the expected profits implies that principal i must be better off under cost-target relative to profit-target (the converse is obviously also true).

Part (i) Consider an equilibrium candidate where both hierarchies are ruled by profit-target contracts. To prove the result we must show that deviating to cost-target is not profitable for a firm shareholders. To this end, it is enough checking that the contract $\mathcal{C}_i^{c,p} \equiv \{q_i^{c,p}(\theta), e_i^{c,p}(\theta), w_i^{c,p}(\theta)\}_{\theta\in\Theta}$ implemented by principal i under cost-target is incentive feasible under profit-target when her rival plays the equilibrium candidate $\mathcal{C}^p \equiv \{q^p(\theta), e^p(\theta), w^p(\theta)\}_{\theta\in\Theta}$.

As a first step we need to characterize $\{q_i^{c,p}(\theta), e_i^{c,p}(\theta)\}_{\theta\in\Theta}$. It is then easy to show that $\underline{IC}$ and $\overline{PC}$ bind in $\mathcal{P}_i^p$ and that the first-order conditions necessary and sufficient for optimality imply $\underline{q}_i^{c,p} = \underline{e}_i^{c,p} = \underline{q}^*$,

$$\overline{e}_i^{c,p} = \overline{q}_i^{c,p} - \frac{\nu}{1-\nu}\Delta\theta,$$

and

$$\overline{q}_i^{c,p} = \overline{q}^* - \frac{\nu}{(1-\nu+\sigma)(1+\sigma)}\Delta\theta - \frac{\nu}{1-\nu} \cdot \frac{\sigma}{1-\nu+\sigma}\Delta\theta,$$

where it is immediate to verify that $\Delta\theta$ small guarantees that $\overline{q}_i^{c,p}$ and $\overline{e}_i^{c,p}$ are strictly positive. Now, notice that $\{q_i^{c,p}(\theta), e_i^{c,p}(\theta)\}_{\theta\in\Theta}$ satisfies the monotonicity condition under cost target, i.e., $\Delta\theta \geq \underline{e}_i^{c,p} - \overline{e}_i^{c,p}$, so that truthful information revelation is guaranteed. In order to complete the proof we need to show that $\{q_i^{c,p}(\theta), e_i^{c,p}(\theta)\}_{\theta\in\Theta}$ also satisfies (19), meaning that $\Delta\theta - \sigma(\underline{q}^* - \overline{q}^p) \geq 0$ and $\underline{q}^* \geq \overline{q}_i^{c,p}$. First, observe that $\underline{q}^* > \overline{q}_i^{c,p}$ follows immediately from the fact that $\underline{q}^* \geq \overline{q}^* \geq \overline{q}_i^{c,p}$. Moreover, simple algebraic manipulations yield:

$$\Delta\theta - \sigma(\underline{q}^* - \overline{q}^p) = \frac{(1-\nu)\Delta\theta}{1-\nu+\sigma} \geq 0.$$

This implies that $\mathcal{C}_i^{c,p} \neq \mathcal{C}^p$ is incentive feasible under profit target. Thus strict concavity of the expected profits together with a revealed preferences argument concludes the proof. $\square$

Part (ii) This claim is proved in three steps. Consider an equilibrium candidate where both organizations are ruled by a cost-target contract.

Step 1 To begin with, we show that profit-target is always a profitable deviation for principal i whenever $\nu \leq 1/2$ given that his rival offers a contract $\mathcal{C}^c \equiv \{q^c(\theta), e^c(\theta), w^c(\theta)\}_{\theta\in\Theta}$. This result can be demonstrated by the same revealed preferences logic used in part (i). Specifically, we now show that principal i has an incentive to play profit-target for all σ whenever $\nu \leq 1/2$ and her rival offers the contract $\mathcal{C}^c$. To this end, it is enough to check that the allocation $\mathcal{C}^c$ satisfies the monotonicity condition (19) associated to $\mathcal{P}_i^p$. The following properties must then hold: $\Delta\theta - \sigma(\underline{q}^* - \overline{q}^c) \geq 0$ and $\underline{q}^* \geq \overline{q}^c$ for all σ. The latter inequality is obviously true, while the former implies:

$$0 \leq \frac{1-\nu(1+\sigma)}{(1-\nu)(1+\sigma)},$$

which holds for all $\sigma \leq (1-\nu)/\nu$. However, since we have assumed $\nu \leq 1/2$ it follows that $(1-\nu)/\nu \geq 1 \geq \sigma$, hence $\sigma \leq (1-\nu)/\nu$ holds for all $\sigma \leq 1$. This implies that the contract $\mathcal{C}^c$ commands an allocation that belongs to the incentive feasible set generated by a profit-target contract; hence, a revealed preferences argument concludes the step.

Step 2 Assume now $\nu > 1/2$, we show that deviating to profit-target is individually profitable for principal i when $\sigma \leq (1-\nu)/\nu$, provided that her competitor offers a contract $\mathcal{C}^c$. To this end, observe that $\nu > 1/2$ implies $0 \leq (1-\nu)/\nu < 1$. Thus, as demonstrated above, principal i has an incentive to play profit-target for $\sigma \leq (1-\nu)/\nu$.

Step 3 Finally, we demonstrate that cost-target is an equilibrium of the game of contractual choices for all $\sigma \geq (1-\nu)/\nu$ and $\nu > 1/2$. Take cost-target as a candidate equilibrium and assume, without loss of generality, that principal i deviates by offering a profit-target contract. To begin with, observe that when $\sigma \geq (1-\nu)/\nu$ a deviation to profit target by principal i entails countervailing incentives since:

$$\Delta\theta - \sigma(\underline{q}^* - \overline{q}^c) = \frac{1-\nu(1+\sigma)}{(1-\nu)(1+\sigma)}\Delta\theta \leq 0.$$

Indeed, in this case, the incentive constraint of the low-cost type under profit-target implies

$$\underline{U}_i \geq \overline{U}_i + \underbrace{\psi(\overline{e}_i) - \psi\left(\overline{e}_i - \frac{1-\nu(1+\sigma)}{(1-\nu)(1+\sigma)}\Delta\theta\right)}_{<0},$$

while the incentive constraint of a high-cost manager implies

$$\overline{U}_i \geq \underline{U}_i + \underbrace{\psi(\underline{e}_i) - \psi\left(\underline{e}_i + \frac{1-\nu(1+\sigma)}{(1-\nu)(1+\sigma)}\Delta\theta\right)}_{>0}.$$

Therefore, only $\overline{IC}$ and $\underline{PC}$ must bind in $\mathcal{P}_i^p$, that is

$$\underline{U}_i = 0,$$

$$\overline{U}_i = \psi(\underline{e}_i) - \psi(\underline{e}_i + \Delta\theta - \sigma(\underline{q}^* - \overline{q}^c)).$$

After a standard change of variables, program $\mathcal{P}_i^p$ rewrites as:

$$\max_{\{(\overline{e}_i, \overline{q}_i, \overline{U}_i), (\underline{e}_i, \underline{q}_i)\}} \mathbb{E}_\theta[P(q_i(\theta), q_j(\theta))q_i(\theta) - C(q_i(\theta), e_i(\theta), \theta) - \psi(e_i(\theta))] - (1-\nu)\overline{U}_i$$
$$\text{s. t. } \overline{U}_i = \psi(\underline{e}_i) - \psi(\underline{e}_i + \Delta\theta - \sigma(\underline{q}^* - \overline{q}^c))$$

Let $\mathcal{C}_i^{p,c} \equiv \{q_i^{p,c}(\theta), e_i^{p,c}(\theta), w_i^{p,c}(\theta)\}_{\theta\in\Theta}$ be the solution of this optimization program. Assuming interior solutions, standard optimization techniques allow to obtain:

$$\overline{q}_i^{p,c} = \overline{q}^* + \frac{\nu}{1-\nu} \cdot \frac{\sigma}{1+\sigma}\Delta\theta,$$

$$\overline{e}_i^{p,c} = \overline{e}^* + \frac{\nu}{1-\nu} \cdot \frac{\sigma}{1+\sigma}\Delta\theta,$$

$$\underline{q}_i^{p,c} = \underline{q}^* - \frac{\sigma}{\nu(1+\sigma)}\Delta\theta - \frac{1-\nu}{\nu}\Delta\theta,$$

$$\underline{e}_i^{p,c} = \underline{e}^* - \frac{2\sigma}{\nu(1+\sigma)}\Delta\theta - \frac{2(1-\nu)}{\nu}\Delta\theta,$$

where for $\Delta\theta$ small enough this is an interior solution. Now we need to verify that this allocation also satisfies the incentive compatibility constraint of a low-cost type. From the monotonicity condition (19) this can be readily verified since for $\sigma \geq (1-\nu)/\nu$ the following inequalities hold:

$$\Delta\theta - \sigma(\underline{q}^* - \overline{q}^c) = \frac{1-\nu(1+\sigma)}{(1-\nu)(1+\sigma)}\Delta\theta \leq 0,$$

and

$$\underline{q}_i^{p,c} - \overline{q}_i^{p,c} = -\frac{\sigma\nu - (1-\nu) + 2(1-\nu)^2(1+\sigma)}{\nu(1-\nu)(\sigma+1)}\Delta\theta < 0,$$

so that $\Psi((q_i^{p,c}(\theta), \tau_i^{p,c}(\theta))_{\theta\in\Theta}, (q_j^c(\theta))_{\theta\in\Theta}) \geq 0$.

We can now complete the proof by comparing the expected profits of principal i on and off the equilibrium path. For any given $\Delta\theta$, let $\pi_i^{p,c}(\Delta\theta)$ denote principal i's expected profit when she deviates from the candidate equilibrium where both firms are ruled by cost-target contracts. Since the model is quadratic, we can use a second-order Taylor approximation around the point $\Delta\theta = 0$ to obtain $\pi_i^{p,c}(\Delta\theta)$ and $\pi^{c,c}(\Delta\theta)$:

$$\pi_i^{p,c}(\Delta\theta) = \lim_{\Delta\theta\to 0}\pi_i^{p,c}(\Delta\theta) + \Delta\theta \lim_{\Delta\theta\to 0}\frac{\partial\pi_i^{p,c}(\Delta\theta)}{\partial\Delta\theta} + \frac{\Delta\theta^2}{2}\lim_{\Delta\theta\to 0}\frac{\partial^2\pi_i^{p,c}(\Delta\theta)}{\partial\Delta\theta^2}.$$

Thus, differentiating $\pi_i^{p,c}(\Delta\theta)$ with respect to $\Delta\theta$, using the Envelope Theorem and taking $\Delta\theta$ small enough we have:

$$\pi_i^{p,c}(\Delta\theta) \approx \lim_{\Delta\theta\to 0} \pi_i^{p,c}(\Delta\theta) - (1-\nu)\Delta\theta \left(\sigma \lim_{\Delta\theta\to 0} \overline{q}_i^{p,c}(\Delta\theta) \frac{\partial \overline{q}^c(\Delta\theta)}{\partial \Delta\theta} - \psi'(\underline{e}^*) \frac{1-\nu(1+\sigma)}{(1-\nu)(1+\sigma)}\right).$$

By the same kind of logic we also obtain:

$$\pi^{c,c}(\Delta\theta) \approx \lim_{\Delta\theta\to 0} \pi^{c,c}(\Delta\theta) - \Delta\theta \left((1-\nu)\sigma \lim_{\Delta\theta\to 0} \overline{q}^c(\Delta\theta) \frac{\partial \overline{q}^c(\Delta\theta)}{\partial \Delta\theta} - \nu\psi'(\overline{e}^*)\right).$$

Taking the difference between $\pi_i^{p,c}(\Delta\theta)$ and $\pi^{c,c}(\Delta\theta)$ and using the fact that $\lim_{\Delta\theta\to 0} \pi_i^{p,c}(\Delta\theta) = \lim_{\Delta\theta\to 0} \pi^{c,c}(\Delta\theta) = (\underline{q}^*)^2$ and $\lim_{\Delta\theta\to 0} \overline{q}^c(\Delta\theta) = \lim_{\Delta\theta\to 0} \overline{q}_i^{p,c}(\Delta\theta) = \underline{q}^*$ we have:

$$\pi_i^{p,c}(\Delta\theta) - \pi^{c,c}(\Delta\theta) \approx \psi'(\underline{e}^*) \left(\frac{1-\nu(1+\sigma)}{1+\sigma} - \nu\right) \Delta\theta,$$

which is clearly negative for all $(\sigma, \nu) \in \Gamma$. This concludes the step.

Gathering steps 1, 2 and 3 the result follows immediately. □

Proof of Proposition 4

The proof can be developed in two simple steps:

Step 1 First, we show that the difference between revenues and costs is higher under the profit-target regime relative to the cost-target regime. Let

$$R^{t,t'} = \mathbb{E}_\theta[(A - q^t(\theta) - \sigma q^{t'}(\theta) - \theta + e^t(\theta))q^t(\theta) - \psi(e^t(\theta))] \quad \text{for} \quad t = c, p,$$

using the first-order conditions with respect to $\overline{q}_i$ of programs $\mathcal{P}_i^p$ and $\mathcal{P}_i^c$ we have:

$$R^{p,p} - R^{c,c} = (1-\nu)\left((\overline{q}^p - \overline{q}^c)(\overline{q}^p + \overline{q}^c) - \frac{(\overline{e}^p - \overline{e}^c)(\overline{e}^p + \overline{e}^c)}{2}\right).$$

Then, from (20) and (21) we get:

$$R^{p,p} - R^{c,c} = \frac{\sigma\nu}{(1-\nu+\sigma)(1+\sigma)} \left(\overline{q}^p - \frac{\overline{e}^p}{2} + \overline{q}^c - \frac{\overline{e}^c}{2}\right) \Delta\theta,$$

using again the definition of $(\overline{q}^p, \overline{e}^p)$ and $(\overline{q}^c, \overline{e}^c)$ it follows:

$$R^{p,p} - R^{c,c} = \frac{\sigma^2\nu^2}{(1-\nu+\sigma)(1+\sigma)^2} \left(\frac{1}{1-\nu+\sigma} + \frac{1}{1-\nu}\right) \frac{\Delta\theta^2}{2} \geq 0,$$

with equality holding only at $\sigma = 0$.

Step 2 We now show that information rents are higher under the cost-target regime relative to the profit-target regime. Since the model is quadratic, we can use a second-order Taylor expansion around the point $\Delta\theta = 0$ to obtain $\underline{U}^{c,c}(\Delta\theta)$ and $\underline{U}^{p,p}(\Delta\theta)$:

$$\underline{U}^{c,c}(\Delta\theta) = \lim_{\Delta\theta\to 0} \underline{U}^{c,c}(\Delta\theta) + \Delta\theta \lim_{\Delta\theta\to 0} \frac{\partial \underline{U}^{c,c}(\Delta\theta)}{\partial \Delta\theta} + \frac{\Delta\theta^2}{2} \lim_{\Delta\theta\to 0} \frac{\partial^2 \underline{U}^{c,c}(\Delta\theta)}{\partial \Delta\theta^2},$$

and,

$$\underline{U}^{p,p}(\Delta\theta) = \lim_{\Delta\theta\to 0} \underline{U}^{p,p}(\Delta\theta) + \Delta\theta \lim_{\Delta\theta\to 0} \frac{\partial \underline{U}^{p,p}(\Delta\theta)}{\partial \Delta\theta} + \frac{\Delta\theta^2}{2} \lim_{\Delta\theta\to 0} \frac{\partial^2 \underline{U}^{p,p}(\Delta\theta)}{\partial \Delta\theta^2}.$$

Now, because $\lim_{\Delta\theta\to 0} \underline{U}^{p,p}(\Delta\theta) = \lim_{\Delta\theta\to 0} \underline{U}^{c,c}(\Delta\theta) = 0$, and we have assumed $\Delta\theta$ small, neglecting the second-order terms we have:

$$\underline{U}^{c,c}(\Delta\theta) \approx \Delta\theta \lim_{\Delta\theta\to 0} \left(\frac{\partial \underline{U}^{c,c}(\Delta\theta)}{\partial \overline{e}} \cdot \frac{\partial \overline{e}^{c}(\Delta\theta)}{\partial \Delta\theta} + \frac{\partial \underline{U}^{c,c}(\Delta\theta)}{\partial \Delta\theta} \right),$$

and,

$$\underline{U}^{p,p}(\Delta\theta) \approx \Delta\theta \lim_{\Delta\theta\to 0} \left(\frac{\partial \underline{U}^{p,p}(\Delta\theta)}{\partial \overline{e}} \cdot \frac{\partial \overline{e}^{p}(\Delta\theta)}{\partial \Delta\theta} + \frac{\partial \underline{U}^{p,p}(\Delta\theta)}{\partial \overline{q}_j} \cdot \frac{\partial \overline{q}^{p}(\Delta\theta)}{\partial \Delta\theta} + \frac{\partial \underline{U}^{p,p}(\Delta\theta)}{\partial \Delta\theta} \right).$$

Simple algebra thus allows to obtain:

$$\underline{U}^{p,p}(\Delta\theta) - \underline{U}^{c,c}(\Delta\theta) \approx -\psi'(\underline{e}^{*}) \frac{\sigma}{1-\nu+\sigma} \Delta\theta \leq 0,$$

with equality holding only at $\sigma = 0$.

Finally, since the expected virtual surplus of each principal can be written as:

$$\pi^{t,t'} = \mathbb{E}_\theta[(A - q^t(\theta) - \sigma q^{t'}(\theta) - \theta + e^t(\theta))q^t(\theta) - \psi(e^t(\theta))] - \mathbb{E}_\theta[U^t(\theta)],$$

gathering steps 1 and 2 yields the result. □

Proof of Proposition 5

Let $\pi^{p,c}$ (resp. $\pi^{c,p}$) be the expected profit of a principal offering the contract $\mathcal{C}^p$ (resp. $\mathcal{C}^c$) when his rival offers $\mathcal{C}^c$ (resp. $\mathcal{C}^p$). By definition of risk dominance, the result is established whenever the following inequality holds:

$$\frac{1}{2}\pi^{p,p} + \frac{1}{2}\pi^{p,c} \geq \frac{1}{2}\pi^{c,c} + \frac{1}{2}\pi^{c,p}$$

This is proved in two steps.

Step 1 First, we show that in the low-cost state a manager accepting a contract $\mathcal{C}^p$ obtains an (actual) expected rent which is lower than that he would obtain by signing $\mathcal{C}^c$. Indeed, these expected rents are defined by:

$$U_i^p = \frac{1}{2}\underline{U}^{p,p} + \frac{1}{2}\underline{U}_i^{p,c}, \tag{22}$$

where $\underline{U}_i^{p,c} \in [0, \underline{U}^{p,p}]$; and

$$U_i^c = \frac{1}{2}\underline{U}^{c,c} + \frac{1}{2}\underline{U}^{c,p}, \tag{23}$$

where $\underline{U}^{c,p} = \underline{U}^{c,c}$.

Equation (22) implies that in the low-cost state a manager accepting the contract $\mathcal{C}^p$ obtains with probability 1/2 a rent equal to $\underline{U}^{p,p}$, i.e., that he would obtain in a profit-target regime, and with probability 1/2 an off-equilibrium rent which arises when his rival receives an offer $\mathcal{C}^c$. If the principal pays what he had promised irrespective of the realized profit, the maximal rent paid to this agent is clearly $\underline{U}^{p,p}$; if instead the principal decides not to accomplish his contractual obligations because, in the continuation game following a message $m_i = \underline{\theta}$, realized (average) profits $\widehat{\tau}^{p,c} = A - \underline{q}^p - \sigma\underline{q}^c - \underline{\theta} + \underline{e}^*$ turn out to be different than promised ones $\underline{\tau}^p = A - \underline{q}^p(1+\sigma) - \underline{\theta} + \underline{e}^*$, then this rent gets its lower bound which is zero.

Equation (23) instead implies that the expected rent of a manager signing $\mathcal{C}^c$ is precisely equal to that he would obtain in the cost-target regime because his reward does not depend on the action of the competing firm, i.e., $\underline{U}^{c,c} = \underline{U}^{c,p}$.

Therefore, since from the proof of Proposition 4 we know that $\underline{U}^{p,p} \leq \underline{U}_i^{c,c}$, it follows:

$$U_i^p = \frac{1}{2}\underline{U}^{p,p} + \frac{1}{2}\underline{U}^{p,c} \leq \underline{U}^{p,p} \leq \underline{U}^{c,c} = U_i^c,$$

This implies that the expected agency costs paid by a principal offering a contract $\mathcal{C}^p$ are lower than those associated to a contract $\mathcal{C}^c$.

Step 2 We now show that $R^{p,p} + R^{p,c} \geq R^{c,c} + R^{c,p}$. First, from Proposition **4** we already know that $R^{p,p} > R^{c,c}$, hence we must only check that $R^{p,c} \geq R^{c,p}$. Let

$$R^{p,c} = \mathbb{E}_\theta[(A - q^p(\theta) - \sigma q^c(\theta) - \theta + e^p(\theta))q^p(\theta) - \psi(e^p(\theta))],$$

and

$$R^{c,p} = \mathbb{E}_\theta[(A - q^c(\theta) - \sigma q^p(\theta) - \theta + e^c(\theta))q^c(\theta) - \psi(e^c(\theta))].$$

Now, taking a second-order Taylor approximation around the point $\Delta\theta = 0$ and assuming $\Delta\theta$ small, one has:

$$\frac{R^{p,c}(\Delta\theta)}{\psi'(\underline{e}^*)} \approx (1-\nu)\left(\frac{1}{2}\psi'(\underline{e}^*) - \frac{1-\nu(1+\sigma)}{(1-\nu)(1+\sigma)}\Delta\theta\right) + \nu\psi'(\underline{e}^*),$$

and

$$\frac{R^{c,p}(\Delta\theta)}{\psi'(\underline{e}^*)} \approx (1-\nu)\left(\frac{1}{2}\psi'(\underline{e}^*) - \frac{1-\nu}{1-\nu+\sigma}\Delta\theta\right) + \nu\psi'(\underline{e}^*).$$

Observe then that for $(\nu, \sigma) \in \Gamma$, one must have $1 - \nu(1+\sigma) \leq 0$, hence it immediately follows that $R^{p,c}(\Delta\theta) > R^{c,p}(\Delta\theta)$. This concludes the step.

Finally, the proof follows from gathering together steps 1 and 2. □

Proof of Proposition 6

The proof of this result follows directly from step 1 of the proof of Proposition 4. □