Ownership, Control, and Collusion*

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Abstract

The paper addresses the effects of the separation of ownership and control on long-run competition in oligopolies. It finds that when managers have the preference for smooth time-paths of profits revealed by the evidence on "income smoothing," manager-led firms can sustain any collusive agreement at lower discount factors than owner-led ones. Most common managerial incentives – "low-powered" schemes with monetary bonuses and/or incumbency rents – make collusion supportable at *any* discount factor. When managers are in control, "price wars during booms" need not occur: the most collusive price tends to be pro-cyclical.

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1 Introduction

A highly debated contribution by Michael Jensen and Kevin Murphy (1990) revealed that, at least until the mid '80s when the "stock-options wave" began, the compensation of U.S. top managers has typically had a low pay-performance sensitivity.[1] Steven Kaplan (1994a,b) found top executives to have similar incentives in other developed countries, such as Germany and Japan, where no stock-options wave has taken place yet. Agency theory teaches us that when good indicators of managerial performance are available – as they are for CEOs (current and future profits and stock prices) – high-powered managerial incentives should be highly beneficial to firm owners. Why is it that, for such a long time and in so different countries, shareholders have forgone these benefits and faced the agency costs linked to low-powered managerial incentives?

Three decades of empirical research on "income smoothing" revealed that managers invest time, effort and firms' resources, and even use barely legal accounting tricks, in order to smooth accounting profits in time.[2] In a recent paper on the subject, Drew Fudenberg and Jean Tirole (1995) note that income smoothing involves substantial real costs, among which are:

> "...poor timing of sales, overtime incurred to accelerate shipments, disruption of the suppliers' and customers' delivery schedules, time spent to learn the accounting system and tinker with it..." (p. 76).

Why is it that shareholders continue to face the costs of income smoothing practices, instead of suitably modifying managers' incentive schemes?

This paper focuses on the effects of these observed compensation practices on firms' long-term competitive attitudes. Its main finding is that as long as managers have the kinds of low-powered incentives that induce "income smoothing," the separation between ownership and control – as well as any more limited form of delegation to professional managers that includes pricing decisions – greatly enhance firms' ability to sustain tacit collusion. This finding offers a new, joint explanation for the empirical findings above, at least for the case of mature oligopolistic industries: A strong pro-collusive effect can outweight the above mentioned costs, and transform such puzzling compensation practices into profitable alternatives to high-powered incentives.

The phenomenon of tacit collusion among oligopolistic firms has been well understood thanks to three decades of research on repeated games.[3] However, most previous

[1] See, also, Sherwin Rosen (1992); Charles Hadlock and Gerald Lumer (1997); and Kevin Murphy (1998).

[2] Restricting attention to more recent studies, see Paul Chaney and Craig Lewis (1998); Mark De Fond and Chul Park (1997); Eero Kasanen *et. al.* (1996); Robert Holthausen *et al.* (1995); Jennifer Gaver *et al.* (1995); Kenneth Merchant (1989); and Paul Healy (1985).

[3] Classical references include James Friedman (1971); Robert Aumann and Lloyd Shapley (1976); Ariel

supergame-theoretic analyses of collusion confined themselves to the standard assumption that firms maximize discounted expected profits. Since in the real world many interacting factors determine the shape of firms' objective function, it is interesting to understand how these factors affect firms' ability to collude. In particular, economists have realized for a long time that when ownership is separated from control, firms tend to pursue objectives different from profit maximization.[4]

Here we wish to keep an empirical focus, so we start from what we know about real-world managers' objectives, that is, from the empirical evidence discussed at the beginning. To analyze the long-term product market implications of income-smoothing managers and low-powered incentive schemes, we embed these pieces of evidence in a classical repeated oligopoly model.

First, we find that – whatever the reason behind it – managers' observed "preference for smooth profit streams" carries with it a "preference for collusive behavior." Firms whose pricing policy is in the hands of managers that prefer smooth profit streams can support any collusive agreement at lower discount factors than those at which owner-led firms can. This is because the preference for smooth profit streams both reduces managers' appreciation of short-run profits from unilaterally breaking a collusive agreement, and it increases their sensitivity to losses from the punishment phase that follows such a breach.[5]

Several theoretical explanations have been proposed for managers' attempts to smooth firms' profits. We explore more in detail the product market implications of two of the most influential among these explanations.

We begin with Paul Healy's (1985) hypothesis that income smoothing practices are driven by the commonly used "bonus contracts" that pay managers in each period a fixed salary, plus an additional monetary bonus only awarded if a predetermined target level of profits is achieved. We find that such contracts, whether long-term or short-term, act as powerful incentives for collusion. Bonus contracts are able to make even the joint monopoly collusive agreement supportable in equilibrium at any level of the discount factor.

More recently, Drew Fudenberg and Jean Tirole (1995) have proposed an explanation of income smoothing based on incumbent managers' rents (e.g. private benefits of control), owners' inability to commit to long-term contracts, and "information decay" (the higher

Rubinstein (1979); Ed Green and Robert Porter (1984); Drew Fudenberg and Eric Maskin (1986); Julio Rotemberg and Garth Saloner (1986); and Dilip Abreu (1986, 1988).

[4]Most notably, scholars involved in the "managerial" theory of the firm, such as Herbert Simon (1957); William Baumol (1958); Richard Cyert and James March (1963); Robin Marris (1964); Oliver Williamson (1964); and Jensen and William Meckling (1976).

[5]The result does not depend on imperfections in credit markets. The evidence on income smoothing reveals that managers prefer smooth streams of firms' *accounting profits*. With perfect credit markets managers can freely save and borrow to smooth the time profile of their own income, or that of the firm's available funds, but they cannot affect (at least legally) the firm's accounting profits.

informational content of more recent performance indicators). We consider a simple "reduced form" of their optimal contracting model, a short-term wage contract with private benefits for the incumbent manager, and a replacement rule by which the manager is not reappointed if the firm's profits fall below a certain cut-off level. We find that the fear of losing future rents by being replaced during the low-profits punishment phase that follows a deviation deters managers from breaking any collusive agreement which delivers per-period profits higher than the cut-off level. As with short-term bonus contracts, the joint monopoly collusive agreement becomes supportable at any level of the discount factor.

These results provide an additional explanation for why shareholders tolerate the mismanagement costs linked to income smoothing. In oligopolistic environments the same kinds of incentives that induce such costly practices also allow shareholders to enjoy high collusive profits. The results also make Jensen and Murphy's (1990) findings appear less surprising, at least for mature oligopolistic industries. In such industries low-powered incentives – such as bonus contracts or wage contracts with incumbency rents – are "optimal," in the sense that they induce a kind of "satisfying" managerial behavior that eventually maximizes firms' profits.[6]

The other set of results in the paper regards the cyclical behavior of collusive prices. We find that when managers are under the low-powered incentive schemes described above or, for any other reason, have a preference for smooth time-paths of profits, Rotemberg and Saloner's (1986) "price wars during booms" need not occur. This is because in good states of demand income-smoothing managers have a lower marginal valuation of additional short-run gains from deviations than in bad states of demand. This "wealth effect" works against the "size effect" identified by Rotemberg and Saloner, and dominates it when managers are sufficiently averse to intertemporal substitution in firm profits. These last results provide an explanation for the mixed empirical evidence available on the Rotemberg and Saloner model's predictions (Glenn Ellison, 1994).

1.1 Related literature

Above we mentioned the relations between this paper, the theoretical literatures on tacit collusion in repeated oligopolies and on the managerial theory of the firm, and the empirical literatures on top-managers pay-performance sensitivity and on income smoothing. Another line of research to which Sections 3 and 4 of this paper are closely related is the one on "strategic delegation" started by John Vickers (1985) and Chaim Fershtman (1985). Building on Thomas Schelling's (1960) insight that contracts with third parties

[6] This partly vindicates Herbert Simon's claim that firms/managers most often aim at a "satisfying performance," not at maximizing profits. Since this kind of "administrative behavior" leads to better results in oligopolies, it needs not be driven out by "profit maximization" in the process of economic evolution (see Section 7).

may have strategic effects, this literature explores the consequences of delegating control to managers with preferences or incentives different from those of the owners in oligopolies (e.g. Fershtman and Kenneth Judd, 1987; Steven Sklivas, 1987; Fershtman, Judd and Ehud Kalai, 1991; Michael Katz, 1991; David Reitman, 1993).

The most closely related papers within this strand of literature are Fershtman, Judd, and Kalai (1991), and perhaps Michele Polo and Piero Tedeschi (1992) and Rajesh Aggarwal and Andrew Samwick (forthcoming). Fershtman, Judd, and Kalai (1991) is more closely related to our Section 3, since these authors obtain a "folk theorem" for classical two-stage delegation games where owners use "target compensation functions," incentive schemes that guarantee delegates a fixed prize as long as they keep their principal's utility above a certain level. Polo and Tedeschi, and Aggarwal and Samwick are related to our paper because they also obtain pro-collusive effects of delegation, although by allowing managers' contracts to be explicitely and positivey related to the performance of the competing firms.

Model and results in this paper are well distinct from those in these earlier contributions. From a methodological point of view, to analyze the effects of delegation of control on firms' long-term competitive behavior we depart from all previous work on the subject by letting firms interact repeatedly in time.[7] From a positive point of view, among other things we find that delegation makes full collusion supportable at any level of the discount factor with the simple types of low-powered managerial incentive contract that one observes in reality (see Murphy, 1998). These contracts are not "target compensation functions"; for example, managers under bonus contracts incurr a net loss (of future bonuses) when they increase the owner's payoffs by deviating unilaterally from a collusive agreement. Also, these observed contracts are not linked – neither positively nor negatively – to competing firms' performance, they are conditional on the firm's *own* profits only.[8]

[7]Previous contributions model strategic delegation as a two-stage game, where a first stage in which owners choose simultaneously their managers' incentive schemes is followed by a second-stage simultaneous market interaction between managers. However, the appointment of a CEO and the design of his compensation package are decisions taken relatively infrequently in the life of a firm, compared to ordinary pricing and quantity-setting decisions. A one-shot delegation game followed by a second-stage oligopoly *supergame* between delegates under long-term contracts should be a better approximation for at least some real-world oligopolistic interactions. On the other hand, the owners of oligopolistic firms are likely to interact repeatedly in time through the choice of their managers' incentives. Therefore, an infinitely repeated game whose stage game is a "classical" two-stage delegation game should shed further light on the effects of the separation of ownership and control on tacit collusion. This paper considers both these situations.

[8]Incentive contracts explicitly and positively related to competing firms' performance would evidently lead managers to internalize market externalities and behave less aggressively. However, to our knowledge, such rarely observed incentives would be questioned by the competition authorities of most developed

2 "Income smoothing" managers and product market rivalry

2.1 A simple model

Consider a homogeneous good oligopoly where N identical firms compete in price. Time is discrete and trade occurs simultaneously in each period $t = 1, 2, ...$ At the beginning of each period each firm announces its current price. Let c denote the firms' constant and identical marginal cost, δ owners' and managers' common intertemporal discount factor, and p_i^t the price that firm i announces in period t. Demand is a decreasing and continuous function $Q(p^{mt})$ of price, where $p^{mt} = \min_i\{p_i^t\}$. When the N firms announce identical prices, demand is shared equally. When the quoted prices differ, all the consumers buy from the subset of firms which quoted the lowest price. These firms must meet all the demand at the announced price and allocate it equally among them. It is also assumed that total industry profits are concave in price and reach a maximum at $p^{mt} = p^M$, where $p^M = \arg\max_p (p - c)Q(p)$ is the monopoly price.

An equilibrium outcome in this market is an infinite path of prices and associated profits vectors $\langle p^t, \pi^t \rangle_{t=0}^{\infty}$. As long as no collusive agreement is implemented, firms earn zero profits as they are caught in the unique Nash equilibrium of the static Bertrand game, with $p_i^{mt} = c$ and $\pi_i^t = 0$, for every i and t.

We focus first on stationary collusive agreements supported by trigger strategies, that is, by the threat of reverting forever to the Nash equilibrium of the static game (James Friedman, 1971). This simplifies analysis and exposition, and does not restrict the scope of the results.[9] Moreover, real-world tacit collusive agreements seldom consist of complex non-stationary equilibrium paths supported by sophisticated enforcing mechanisms.[10] Extensions to different market structures and to more sophisticated punishment strategies are discussed in Section 5.1.

A stationary collusive agreement to set $p_i^t = p^* > c$, $\forall i, t$ can be supported by trigger strategies if and only if for every firm i, the expected gains from respecting the agreement outweigh the short-run gains from deviating from it. Formally, the condition is as follows:

$$\frac{1}{1-\delta}\frac{1}{N}(p^* - c)Q(p^*) \geq (p^* - c)Q(p^*) \tag{1}$$

countries.

[9] With repeated Bertrand competition the most collusive market equilibria are stationary with colluding firms behaving as a monopolist in each period, while unrelenting trigger strategies are "optimal punishments." They keep players at their security levels, so that no complex punishment mechanism can enlarge the set of supportable equilibria (Abreu, 1986).

[10] Firms are dealing with forbidden implicit contracts on which exchanges of information and other forms of communication are risky. In a world where information is typically imperfect and costly and coordination difficult, the simplicity of stationary equilibria and trigger strategies may be important for tacit collusive agreements to be implementable.

$$\Rightarrow \delta \geq 1 - \frac{1}{N}.$$

If condition 1 is not satisfied, tacit collusion is not supportable. To simplify notation, in the rest of the paper we will sometimes let π_i^* denote the per-period collusive profits of a firm i, $\frac{1}{N}(p^* - c)Q(p^*)$, and $\widehat{\pi}_i^*$ denote short-run profits from deviating unilaterally from that collusive agreement $(p^* - c)Q(p^*)$.

2.2 "Income-smoothing managers" and collusive behavior

The empirical literature on income smoothing mentioned in the introduction reveals that real-world managers have a robust preference for smooth time paths of firms' accounting profits. The preference for smooth profits, that is, the aversion to intertemporal substitution in firm profits implies decreasing marginal utility of profits within each period, i.e. a strictly concave instantaneous objective function. When income-smoothing managers take price-setting decisions, firms' objective functions should incorporate this preference. In our model, a manager-led firm i should therefore maximize, in each period τ, the objective function $\sum_{t=\tau}^{\infty} \delta^t U(\pi_i^t)$, with U strictly concave. On the other hand, to our knowledge, there is no evidence of income smoothing practices for owner-led firms. This leads us to the first result.

Proposition 1 *Suppose owners maximize discounted expected profits, while managers have a preference for smooth profit streams. Then, the separation between ownership and control facilitates collusion: It allows any tacit collusive agreement to be supported in subgame perfect equilibrium at a lower minimum discount factor.*

Proof: Please see the Appendix.

The intuition for this result is that income-smoothing managers' strictly concave instantaneous objective functions relax the necessary and sufficient conditions for any collusive agreement to be supported in equilibrium, for two reasons:

1. they reduce the relative value of short-run gains from unilateral deviations from the agreement (they are evaluated at relatively lower marginal utility); and

2. they increase the relative value of the losses from the punishment phase which follows a deviation (they are evaluated at relatively higher marginal utility).

The necessary conditions for any given collusive agreement to be supportable in equilibrium are linear in three parameters: the discount factor δ; the equilibrium profit stream $\left\{\pi_i^t = \pi_i^*\right\}_{t=\tau}^{\infty}$; and the stage-game's payoff structure, parametrized here by $\hat{\pi}_i^*$. The concavity of the instantaneous utility function makes such conditions less stringent and therefore, given two of the parameters, it enlarges the set of values of the third parameter which satisfy the relation. This leads to the following remark.

Remark 1 *Proposition 1 implies that, given the discount factor δ, managers' preference for smooth profit streams:*

(i) (weakly) enlarges the set of collusive agreements that firms can support in any given oligopoly;

(ii) enlarges the set of oligopolies (parametrized by $\hat{\pi}_i^*$) in which firms are able to support any given collusive profit stream.

A second remark is in order.

Remark 2 *When firms are conglomerates and there is multimarket contact, an additional pro-collusive effect – due to income-smoothing managers' higher valuation of losses from simultaneous punishments and lower valuation of gains from simultaneous deviations in more markets – adds to the effects identified by Proposition 1 (see Giancarlo Spagnolo, 1999).*

2.3 Extensions

2.3.1 Other reasons to "smooth-and-collude"

Proposition 1 may appear to best fit the explanation of income smoothing offered by Richard Lambert (1984) and Ronald Dye (1988), by which financially constrained managers under share contracts smooth their own income in time by smoothing firms' profits. However, the result applies whatever is the specific factor that leads managers to have a preference for smooth streams of firms' profits. For example, managers' preference for discretion in the form of "free cash flow" identified by Jensen (1986) should also induce a preference for smooth time paths of profits when information asymmetries make external finance costly and dividend policy rigid. An alternative explanation for income smoothing, provided by Joshua Ronen and Samcha Sadan (1981) and Brett Trueman and Sheridan Titman (1988), assumes that managers act in the interests of shareholders, and that shareholders (and capital markets in general) have a preference for assets delivering smooth returns. In this case it would be factors behind shareholders' preferences – for example financial constraints – that facilitate collusion. More generally, any factor (internal or external to the firm) that makes smoothing profits a profitable policy also makes firms more prone to collude. Therefore, many of the arguments brought up in the finance literature for why firms should smooth profits by "hedging" – such as reducing the tax bill (because the corporate tax is generally not perfectly linear in profits), or limiting the extra cost of external finance (due to information asymmetries) – also identify factors that tend to increase firms' willingness to collude (see Kenneth Froot *et al.*, 1993).[11]

[11]The pro-collusive effect of a strictly concave objective function behind Proposition 1, and the converse pro-competitive effect of strictly convex objective functions it implies, also permit a comparison with the

2.3.2 Demand uncertainty

Rotemberg and Saloner (1986) noted that when demand is subject to stochastic shocks that each period realize before firms set prices, short-run gains from breaking a collusive agreement change together with the realization of the state of the world. High demand implies larger short-run profits obtained by deviating unilaterally from a collusive agreement and capturing the whole market. Instead, the expected losses from the punishment phase, the threat that disciplines the collusive agreement, are constant in expectation across states of the world. Then, when the discount factor binds, the more profitable collusive agreements between profit-maximizing firms need to be conditioned on each period's realization of the shock. When the realized state of demand is high, the agreement must indicate a lower collusive price in order to restrain the stronger temptation to break the agreement. These kinds of agreements would appear to outside observers as "price wars during booms."

What is the cyclical behavior of collusive prices when pricing decisions are in the hands of income-smoothing managers? Let θ denote the stochastic shock that affects demand, so that in our model the demand function becomes $Q = Q(p, \theta)$, with $Q(p, \theta)$ increasing in θ. For simplicity, assume θ to be *i.i.d.* so that in each period $\theta \in \{\theta^L, \theta^H\}$, with $\Pr(\theta = \theta^H) = q$ and $0 < q < 1$. Then we can state the following result.

Proposition 2 *Suppose prices are set by managers with a preference for smooth profit streams. Then price wars during booms need not occur: when managers are sufficiently averse to intertemporal substitution in firms' profits and the discount factor binds, the most collusive price supportable in equilibrium is pro-cyclical.*

Proof: Please see the Appendix.

The intuition behind this result is as follows. When managers are averse to intertemporal substitution their objective function is strictly concave, therefore they have a lower marginal valuation of profits at higher levels of realized profits, that is, when demand is high. This means that in good states of the world firms' marginal valuation of short-run gains from deviation is lower than in bad states of the world. This "wealth" effect works in the opposite direction to the "size" effect identified by Rotemberg and Saloner, and dominates it when managers' preference for smooth profits is sufficiently strong.

work of Voijslav Maksimovic (1988) on the relation between leverage and collusion. In Maksimovic's model, long-term debt with a per-period repayment coupon has a pro-competitive effect because shareholders enjoy all short-run gains from breaking a collusive agreement, while limited liability protects them from part of the losses in the following punishment phase. In light of the proof of Proposition 1, we can reinterpret Maksimovic's result imputing it to the strict convexity of shareholders' objective function induced by the long-term debt with a repayment coupon.

3 Long-term "bonus contracts"

3.1 Preliminaries

In a highly debated contribution, Healy (1985) argued that income smoothing may be driven by managers' monetary incentive schemes, and provided empirical support for his view. He noted that most common managerial incentive schemes have fixed monetary bonuses paid only when profits reach a certain positive target level (see also Murphy, 1998). These "capped" incentives then lead managers to transfer profits from periods in which they are far above or below the level that triggers the bonus, to periods in which they are close but below such a target. Paul Joskow and Nancy Rose (1994) found evidence that Boards themselves discount extreme realizations from managers' compensation, so that managerial incentives tend to be "capped." How do these compensation practices influence firms' competitive attitudes?

In this section we focus on the product-market effects of long-term managerial contracts, so we model delegation as a two-stage game where a first-stage static interaction in which owners choose their delegates' incentives is followed by a second-stage infinitely repeated market game. This strategic structure is reminiscent of Jean Pierre Benoit and Vijay Krishna's (1987) and Carl Davidson and Raymond Denekere's (1990) analyses of excess capacity and collusion in Bertrand supergames. In Section 4 we will consider the case of short-term managerial contracts, which has a less familiar strategic structure.

In both sections we follow the bulk of previous work by assuming managerial incentives to be binding and publicly observable, while secret contract renegotiation is discussed in length in Section 6. We adopt the standard assumption that when managers are indifferent with respect to two or more actions they choose the one that maximizes their firm's profits[12] and, to make the results more clear-cut, we assume that inequality (1) – owners' incentive compatibility condition for collusion being supportable – is not satisfied. Finally, to skip straightforward comparisons between costs (managers' compensation) and benefits (additional collusive profits) of delegation, we assume that owners' disutility of running the firm personally is strictly larger than managers' reservation wage R.[13]

3.2 Long-term bonus contracts and tacit collusion

Because condition (1) is not satisfied, owner-led firms are stuck at the static Bertrand-Nash equilibrium earning zero profits. However, owners may decide – at the foundation

[12] Alternatively, one could let managers' compensation contain a small profit-sharing component, or assume that managers own a small amount of firms' shares.

[13] At the cost of a small loss of generality, we could follow previous work and neglect the possibility that owners retain control (to evaluate these alternative approaches the reader may contrast Spagnolo, forthcoming, with Spagnolo, 1998).

of the industry or in any following period – to hire managers under the commonly used "bonus contracts" to try to improve on their miserable situation.

We define a long-term bonus contract as a stationary sequence of values for the triple of parameters $\left\{W_i, B_i, \pi_i^B\right\}$, where W_i denotes the manager's salary, B_i denotes a positive monetary bonus, and π_i^B denotes the minimum level of the firm's profits that triggers its payment to the manager.[14] Suppose owners can choose between keeping control, hiring a profit-maximizing manager, and hiring a manager under a bonus contract (in which case the owners must also choose the target π_i^B). With long-term contracts the timing of the delegation game is as follows.

- Stage 1: Owners simultaneously decide whether to delegate pricing decisions, and if they do it, they choose the parameters of their managers' incentive contract.
- Stage 2: Managers (if delegation takes place) or owners play the market supergame.

In the second-stage market supergame a manager i under bonus contract with $\pi_i^B > 0$ finds it convenient to respect any tacitly agreed sequence of collusive prices $\left\{p^t = p^*\right\}_{t=0}^{\infty}$ such that

$$\pi_i^B \leq \frac{1}{N}(p^* - c)Q(p^*), \forall i, \tag{2}$$

whatever the discount rate is. This is so because by sticking to the agreement he receives, together with the wage, a stationary flow of bonuses with total discounted expected payoffs $\frac{W_i+B_i}{1-\delta}$. A unilateral deviation from any such collusive agreement leaves the manager's wage unaffected and allows him to get the bonus in the period of the deviation, but triggers a punishment phase during which profits are zero and the bonus is not paid. Discounted expected payoffs from the unilateral deviation are therefore $B_i - \frac{W_i}{1-\delta}$, that is, a net loss of $\delta\frac{B_i}{1-\delta}$.

If all managers are under bonus contracts, the set of collusive prices supportable in subgame perfect equilibrium in the market supergame P^* is non-empty as long as $\sum_{i=1}^{N} \pi_i^B \leq (p^M - c)Q(p^M)$, where the superscript ^{M} indicates the value of a variable at the joint monopoly outcome. This is so because if condition (2) does not hold for one (or more) manager(s), then that manager would deviate from any collusive price (either to try to obtain the bonus at least once or, when this is impossible, because he is indifferent and therefore maximizes the firm's profits). Therefore, as long as $\sum_{i=1}^{N} \pi_i^B \leq (p^M - c)Q(p^M)$ managers can support collusion in the second stage. Furthermore, if all managers have $\pi_i^B = \pi_i^M$, where $\pi_i^M = \frac{(p^M-c)Q(p^M)}{N}$, the joint monopoly agreement is the only stationary

[14] Regarding managers' participation constraint, we can follow Fershtman and Judd (1987) by assuming that managers' real compensation is some function $A(W + B) \geq R$. The parameter A can then be set freely to reflect conditions on the managerial labor market, as managerial behavior is only driven by the step at the target profit level π_i^B, which does not depend on A.

collusive agreement managers can support in equilibrium in the second-stage supergame, whatever the discount factor is.

Consider now the first stage of the delegation game. Can an owner profit by deviating unilaterally from a strategy profile that in the first stage prescribes each owner to delegate control to a manager under a bonus contract with $B > 0$ and $\pi_i^B = \pi_i^M$? If an owner deviates by choosing to keep control or to delegate to a profit-maximizing manager (e.g. setting $B = 0$) collusion cannot be supported and he expects zero profits forever. If an owner deviates by setting $\pi_i^B > \pi_i^M$ the condition $\sum_{i=1}^N \pi_i^B \leq (p^M - c)Q(p^M)$ is violated, collusion cannot be supported and, again, all owners (including the deviating one) get zero profits forever. Finally, if an owner deviates by choosing $\pi_i^B < \pi_i^M$ he cannot gain, but he can lose since even though managers can support collusion in the second stage, his manager may settle with a collusive agreement delivering profits π_i^* with $\pi_i^B \leq \pi_i^* < \pi_i^M$.

This simple reasoning is summarized by the following proposition.

Proposition 3 *By delegating control to managers under long-term bonus contracts with $\pi_i^B = \pi_i^M$, owners can support the joint monopoly collusive agreement in subgame perfect equilibrium of the delegation game at* any *level of the discount factor.*

3.3 Extensions

3.3.1 Richer contract space

We focused on bonus contracts because of their empirical relevance, but the results above remain valid when owners can choose from a larger set of managerial incentive contracts. For example, owners may think of making a manager's compensation a continuous function of firm profits, or a function of sales revenue, which we denote by S_i. Suppose owners can choose the parameters of the following compensation function:

$$W_i + \gamma_i g_i(\pi_i) + \beta_i f_i(S_i) + B_i \cdot 1_{\{\pi_i \geq \pi_i^B\}},$$

where $\gamma_i \geq 0$ and $\beta_i \geq 0$ are coefficients, $g_i(.)$ and $f_i(.)$ are continuous increasing functions, and 1_A is the indicator function on a set A.[15] When $\beta_i > 0$, we assume owners forbid (contractually) managers to choose prices lower than marginal cost, so that owners avoid negative profits if collusion breaks down.[16] Owner i's choice variables in the first-stage delegation game are now $\{\gamma_i, \beta_i, g_i, f_i, B_i, \pi_i^B\}$, and we can state the following lemma.

Lemma 1 *The minimum discount factor at which any collusive agreement (or, given the discount factor, the set of agreements that) can be supported in subgame perfect equilibrium in the delegation game is increasing (decreasing) with γ_i and β_i.*

[15] The indicator function $1_{\{\pi_i \geq \pi_i^B\}}$ assumes value 1 when $\pi_i \geq \pi_i^B$ and 0 otherwise.

[16] This also ensures the existence of the static Nash equilibrium in the market game when incentives for sales are chosen.

Proof: Please see the Appendix.

The point is that under bonus contracts managers have no incentive whatsoever to deviate from a collusive agreement that permits them to obtain the bonuses. Incentive components increasing in profits generate short-run gains from deviation for managers, while leaving their wage during punishment phases unaffected. Incentive components increasing with sales also generate managerial short-run gains from deviation, and they even increase managers' wage during punishments. A simple result follows from Lemma 1.

Proposition 4 *By delegating control to managers under long-term bonus contracts with* $\gamma_i = 0$, $\beta_i = 0$, $B_i > 0$, *and* $\pi_i^B = \pi_i^M$, *owners can still support the joint monopoly collusive agreement in subgame perfect equilibrium at any level of the discount factor.*

A formal proof is not required, as it is straightforward to check that each owner cannot gain by deviating from this strategy profile. By choosing $\gamma_i > 0$ or $\beta_i > 0$ an owner cannot affect collusive profits or the static Bertrand outcome, while he makes his manager's incentive constraint more stringent and therefore destabilizes collusion. On the other hand, as before, the choice of $\pi_i^B < \pi_i^M$ may lead the managers to support a less profitable agreement, while choosing $\pi_i^B > \pi_i^M$ or $B_i = 0$ leads managers to maximize per-period profits, and therefore to the repeated play of the static Bertrand equilibrium.

3.3.2 Demand uncertainty

To analyze the effects of long-term bonus contract on the cyclical behavior of prices we focus on the two extreme cases of fully contractable and non-contractable shocks.

Suppose first that the demand shock θ is contractable, that is, that the shock can be observed ex post by owners and third parties, with or without delay. For example, if there exist independent agencies monitoring the state of demand, a contract could be made contingent on the state of demand reported by one of these agencies. Then we easily obtain the following result.

Proposition 5 *With contractible demand uncertainty, by delegating control to managers under long-term bonus contracts owners can implement the joint monopoly outcome in all states of demand at any level of the discount factor.*

Proof: Please see the Appendix.

That is, with contractible demand uncertainty and long-term bonus contracts there will be no price wars during booms.

Consider now the case in which third parties can never observe any reliable signal of past realizations of demand. Now owners cannot condition incentive contracts on (a verifiable signal of) the state of demand, and the bonus contract is as in Section 3.2. For simplicity we continue assuming that θ is *i.i.d.* and that each period $\theta \in \left\{\theta^L, \theta^H\right\}$, with $\Pr(\theta = \theta^H) = q$ and $0 < q < 1$. The outcome of the delegation game may depend now on managers' ability to coordinate. Let us restrict attention to symmetric agreements, and let φ, with $0 \leq \varphi \leq 1$, parametrize managers' coordination ability so that, when managers are indifferent between several supportable collusive prices, when $\varphi = 1$ they choose the collusive price delivering the highest profit stream, when $\varphi = 0$ they choose the collusive price delivering the lowest profit stream, and so on. Then we can state the following result.

Proposition 6 *When the demand shock is not contractable:*

(i) Owners setting $\pi_i^B = \pi_i^M(\theta^H) = \frac{(p^M - c)Q(p^M, \theta^H)}{N}$ *and managers sustaining collusion is a subgame perfect equilibrium of the delegation game whatever is the discount factor. Moreover, as long as* $(p^M - c)Q(p^M, \theta^L) \geq \frac{(p^M - c)Q(p^M, \theta^H)}{N}$ *and* $\delta \leq \frac{1}{1-q}$*, the monopoly price can be sustained only in high states of demand.*

(ii) When $\frac{1-q}{q} > \frac{(N-1)\left[(p^M - c)Q(p^M, \theta^H) - (p^M - c)Q(p^M, \theta^L)\right]}{(p^M - c)Q(p^M, \theta^L)}$*, there exist a* $\widetilde{\varphi}$*, with* $0 < \widetilde{\varphi} < 1$*, such that for any* $\varphi \geq \widetilde{\varphi}$ *there exist subgame perfect equilibria of the delegation game in which owners set* $\pi_i^B = \pi_i^M(\theta^L)$ *in the first stage and managers sustain collusion in all states in the second stage supergame. As long as* $1 > \varphi \geq \widetilde{\varphi}$*, in this equilibria the collusive price is pro-cyclical.*

Proof: Please see the Appendix.

Therefore, with non-contractable uncertainty price wars during booms can, but need not occur; the collusive price tends to be pro-cyclical.

4 Short-term contracts, incumbency rents, and replacement rules

4.1 Short-term bonus contracts

With long-term contracts, delegation under bonus contracts emerges as a powerful collusive device. How is this finding affected by owners' or managers' inability or unwillingness to commit to long-term contracts?

We continue assuming that condition (1) is not satisfied, and modify the model by considering managerial contracts that last one period only. The two-stage delegation game with an infinitely repeated second stage of Section 3 is replaced by an infinitely repeated oligopoly game with a classical two-stage delegation game as its stage game. Now at the

beginning of each time period owners simultaneously choose whether or not to delegate control to managers and, if they decide to, the parameters of the compensation function. At the end of the same time period delegates or owners interact in a one-shot Bertrand oligopoly game. The timing of period t stage game is therefore as follows.

Stage game t

- Step 1: Owners simultaneously decide whether to delegate pricing decisions and choose managers' incentive contracts.
- Step 2: All players observe the outcome of Step 1, then players in control simultaneously choose prices for period t only.

As in standard repeated games with perfect information, we assume that at the end of each period prices and profits are observed by all players. We can state a result analogous to Proposition 3.

Proposition 7 *By delegating control to managers under short-term bonus contracts, owners can still sustain the joint monopoly collusive agreement in subgame perfect equilibrium at any level of the discount factor.*

Proof: Please see the Appendix.

Even though explicit managerial contracts last one period only, owners and managers are free to agree on *implicit* employment contracts with each other, which are long-term by definition (Bentley MacLeod and James Malcomson, 1989; Lorne Carmichael, 1989). Then, owners have no incentive to deviate from an implicit long-term contract that leads the manager to sustain collusion in the product market, since owners' deviations (changes of the contract, replacement of the manager) are observed by competing firms' managers who can react before any gain from deviation in the product market can be realized. On the other hand, managers always find it convenient to respect the collusive agreement, since their incentive contract is such that they gain nothing by deviating, while after the deviation they are fired and/or kept at their reservation wage forever.[17]

It is straightforward to check that a fully analogous argument applies when managerial contracts last any finite number of periods other than one. The only difference is that in that case owners choose once every T periods, rather than at the beginning of each period.

[17]The equilibrium set with short-term contracts differs from that with long-term contracts only with regard to the case in which managers are kept at their reservation wage R. The results in Section 3 apply for any level of managerial compensation $W_i + B_i \geq R$, while Proposition 7 holds for $W_i + B_i > R$ only. This is because now a fraction (however small) of the collusive rent must be left to the manager to generate the expected gains from compliance necessary to enforce any implicit contract. In MacLeod and Malcomson's (1989) characterization implicit contracts can also be supported when employees are indifferent. Here the strict inequality is needed because of our assumption that, when indifferent, managers maximize firms' profits.

4.2 Incumbency rents and replacement rules

In the case of short-term bonus contracts, the managers' collusive behavior is driven by the "capped" incentive scheme together with the fear of losing future rents. An analogous pro-collusive effect should therefore be linked to managers' fear of losing other common kinds of incumbency rents, such as private benefits of control. As already mentioned, Fudenberg and Tirole (1995) proposed an explanation of income smoothing based on managers' fear of losing incumbency rents. In their optimal contracting model, managers enjoy private benefits of control (the incumbency rents), owners cannot commit to long-term contracts, and performance measures are subject to "information decay" so that new performance measurements are better signals than old ones. In equilibrium, managers under wage contracts incur positive costs in order to smooth reported profits and dividends because, given information decay, some periods of low profits may lead shareholders to replace the manager even if profits have been high in the past.

To characterize the product-market effects of the "aversion to low profits" obtained by Fudenberg and Tirole, we consider a stylized reduced form of their model. Suppose that managerial contracts last one period, that per-period compensation is composed of a flat wage plus some private benefits of control, and that owners use a replacement rule by which the manager is not reconfirmed if profits fall below some lower cut-off level. As in the previous section, each period t stage game is composed of two steps:

Stage game t

- Step 1: Owners simultaneously decide whether to delegate and choose the parameters of managers' compensation.
- Step 2: All players observe the outcome of Step 1, then players in control simultaneously choose prices.

One can state the following proposition.

Proposition 8 *Suppose managers in control enjoy private benefits (or any other kind of incumbency rents independent of profits). Then, by delegating control to managers under short-term wage contracts, owners can still sustain the joint monopoly collusive agreement in subgame perfect equilibrium at any level of the discount factor.*

Proof: Please see the Appendix.

Private benefits of control and other incumbency rents coupled with the termination threat have a pro-collusive effect analogous to that of short-term bonus contracts. Again, each owner has no incentive to deviate from an implicit long-term contract that in equilibrium leads the manager to sustain collusion in the product market, since the owner's

deviations (a change of the contract or the replacement of the manager) is observed by competing firms' managers who react before any gain from deviation can be realized. On the other hand, as long as managers under wage contract enjoy incumbency rents, they find it strictly convenient to respect any collusive agreement that allows them to be reappointed and enjoy rents in future periods.

4.3 Extensions

4.3.1 Richer contract space

Suppose that managerial contracts last one period only, managers enjoy per-period private benefits of control B_i, and owners reconfirm the manager for the next period only if profits are above some lower cut-off level π_i^B (or, equivalently, suppose that managers have a bonus component in the short-term compensation function). Further, suppose that owners can also choose the parameters of the following per-period monetary compensation function:

$$W_i + \gamma_i g_i(\pi_i) + \beta_i f_i(S_i),$$

where as before W_i is a flat salary, $\gamma_i \geq 0$ and $\beta_i \geq 0$ are coefficients, and $g_i(.)$ and $f_i(.)$ are continuous increasing functions. Again, we assume that owners forbid managers contractually to choose prices lower than the marginal cost when $\beta_i > 0$. Now (provided that $W_i + B_i > R$) in Step 1 of each time period, owners' strategically relevant choice variables are $\left\{\gamma_i, \beta_i, g_i, f_i, \pi_i^B\right\}$. The logic behind the results in the previous subsections still applies. We can state a lemma analogous to Lemma 1.

Lemma 2 *When managers are under short-term bonus contracts or wage contracts with incumbency rents, the minimum discount factor at which any collusive agreement can be supported in subgame perfect equilibrium in the infinitely repeated delegation game increases with γ_i and β_i.*

Proof: Please see the Appendix.

Again, managers who are paid a flat wage and enjoy private benefits of control have no incentive whatsoever to deviate from a collusive agreement that permits them to be reconfirmed every period. Instead, incentive components increasing in profits generate short-run gains from deviation for managers, while incentive components increasing with sales also increase managers' wage during punishments. Therefore we can write a result analogous to Proposition 4.

Proposition 9 *By delegating control to managers under short-term bonus contracts or wage contracts with incumbency rents, with $\gamma_i = 0$, $\beta_i = 0$, $B_i > 0$, and $\pi_i^B = \pi_i^M$, owners can still support the joint monopoly collusive agreement in subgame perfect equilibrium at any level of the discount factor.*

Again, a formal proof is not required as it is straightforward to check that each owner cannot gain by deviating from this strategy profile. By choosing $\gamma_i > 0$ or $\beta_i > 0$ an owner cannot affect collusive profits, while he makes his manager's incentive constraint more stringent and therefore destabilizes collusion. On the other hand, as before, the choice of $\pi_i^B < \pi_i^M$ may lead the managers to accept a less profitable agreement, while choosing $\pi_i^B > \pi_i^M$ or $B_i = 0$ leads managers to maximize per-period profits, and therefore to the repeated play of the static Bertrand equilibrium.

4.3.2 Demand uncertainty

Suppose the demand shock θ, or a reliable proxy of it, can be observed ex post by third parties, with or without delay. Then, even when contracts are short-term, bonuses or replacement can be made contingent on the (proxy of the) state of demand, so that statements analogous to Proposition 5 can be proved along the lines of the proofs of Propositions 7 and 8. Then no price wars during booms should be expected. Suppose, instead, that no reliable proxy of θ can ever be observed by courts. Then contracts cannot be conditioned on the shock, and only statements analogous to Proposition 6 can be proved along the lines of the proof of Propositions 7 and 8. Then price wars during booms may, but need not occur; the collusive price may again be pro-cyclical.

5 Discussion

5.1 Alternative specifications of the model

5.1.1 Market structure

We focussed on a repeated Bertrand oligopoly, but most results directly apply to other standard market structures (Cournot competition and price competition with differentiated products or capacity constraints). The only required modification to the proofs is the addition of a stream of positive profits during the punishment phase, which leaves the logic of the reasoning unaffected.

For example, consider Proposition 3, and let $\pi_i^N > 0$ denote the static Nash equilibrium profits which firms earn during the punishment phase when the stage-game oligopoly is not homogeneous-good Bertrand. In the second stage of the game of Section 3.2 each manager under a bonus contract will now find it convenient to stick to any collusive agreement delivering per-period profits π_i^A such that

$$0 < \pi_i^N < \pi_i^B \leq \pi_i^A, \forall i,$$

and all the following reasoning holds unchanged. As long as $\pi_i^B > \pi_i^N$, the reasoning regarding the first-stage delegation game also holds unchanged, and owners lose by setting

$\pi_i^B \leq \pi_i^N$. Analogous arguments apply to the other results regarding long-term contracts.

The check is even more straightforward in the case of short-term contracts. Then managers are not reappointed after a deviation has driven firms into a market war; therefore, firm profits during punishment phases (i.e. market structure) are irrelevant for managers' behavior.

5.1.2 Incentives for sales with Cournot competition

Suppose firms compete in output. Since Stackelberg profits, denoted by π_i^S, are typically lower than profits at the joint monopoly equilibrium, owners who expect other owners to choose bonus contracts with $\pi_i^B = \pi_i^M$ lose strictly by deviating and choosing aggressive managerial incentives linked to sales revenue, such as those considered in Fershtman and Judd (1987) and Sklivas (1987) (FJS from now on).[18] However, if collusion is not sustained or breaks down and managers start playing the static Nash equilibrium, each owner would be better off if he had unilaterally chosen incentives linked to sales ($\beta > 0$). Then, owners may wish to coordinate on a more robust equilibrium of the delegation game, both in the case of long and short term contracts. One such equilibrium has owners giving managers a "mixed" incentive contract with a pro-collusive bonus together with an aggressive FJS-type sales-related incentive component. To see this, consider a Cournot duopoly where a manager's per-period compensation can be composed of an incentive scheme linear in per-period profits and in sales revenue, plus an additional bonus:

$$\rho_i \left(\alpha_i \pi_i + (1-\alpha_i) S_i\right) + (1-\rho_i) B_i \cdot 1_{\left\{\pi_i \geq \pi_i^B\right\}}.$$

Now each owner i's relevant strategy space in the first stage of the delegation game is the set of parameters $\left\{\rho_i, B_i, \alpha_i, \pi_i^B\right\}$. Let α^{FJS} denote the equilibrium level of the parameter α obtained in the FJS two-stage duopoly models. We get immediately a result analogous to Proposition 4.

Proposition 10 *When incentives linked to sales are feasible and firms compete in output, by delegating control under a mixed managerial contract with $\alpha = \alpha^{FJS}$, $\pi_i^B = \pi_i^M$, $B_i > 0$, and $\rho_i > 0$ but small enough to satisfy managers' incentive compatibility constraint at the joint monopoly agreement, owners can support this agreement in subgame perfect equilibrium of the delegation game at any level of the discount factor.*

Proof: Please see the Appendix.

The point is that the pro-collusive effects of capped bonuses and of private benefits of control remain when these are only part of a more complex managerial compensation

[18] We are not aware of any general study on the relation between Stackelberg profits and profits at the symmetric joint monopoly agreement, but in all the simple explicit examples we solved, we always obtained $\pi_i^S \leq \pi_i^M$.

package. Moreover, when owners use the mixed contract described above, if an owner deviates optimally by choosing $\rho_i = 1$ the competing firm's manager reacts by maximizing only the FJS-type part of his incentive scheme, since whatever he does he cannot get his bonus. Therefore, when an owner deviates, instead of π_i^S he obtains the low equilibrium profits of the FJS model $\pi_i^{FJS} < \pi_i^N$, both in the period of the deviation and in the following periods. This mechanism ensures that deviating owners incur a direct loss in the same period of the deviation, and that if one owner deviates by choosing aggressive FJS-type incentives other owners lose less, as their managers will have as aggressive incentives as those of the deviating owner's manager. Note that this applies independently of whether π_i^S is $>, =$, or $<$ than π_i^M.

5.1.3 Renegotiation-proof punishment strategies

Although in repeated Bertrand oligopolies unrelenting trigger strategies are an "optimal punishment" that keeps firms at their security levels (Abreu, 1986), these strategies are not renegotiation-proof, and indeed no renegotiation-proof punishments can be built in a repeated Bertrand game when renegotiation is costless.[19] On the other hand, as persuasively argued by Barbara McCutcheon (1997), in the case of collusive agreements between firms renegotiation costs tend to be positive, although small, because positive is the increased risk of being caught while renegotiating and fined by the competition authority. In this case the optimal renegotiation-proof punishment in a Bertrand supergame consists in pricing competitively for a finite number of periods such that the loss of gains from cooperation caused by the price-war is just below the cost of renegotiation (for a more formal treatment see Andreas Blume, 1994).

All the results of this paper continue to hold when these renegotiation-proof punishment strategies are adopted instead of trigger strategies. The pro-collusive effect of income-smoothing managers (Proposition 1) is even strengthened in this framework since the cost of renegotiation is concentrated in time (in the period of the fine), and is therefore larger for income-smoothing managers, whose marginal utility of firms' profits is higher at low levels of profits, than for owners. Therefore, for any given cost of renegotiation, income-smoothing managers can use the tougher threat of a longer price war to enforce collusion, which adds to the other pro-collusive effects identified by Proposition 1.[20]

Regarding the results with long-term contracts, it is straightforward to check that Propositions 3 to 6 hold unmodified for any finite length of the punishment phase. For the case of short-term managerial contracts we can say something more general: the results regarding short-term contracts hold whatever punishment strategies owners use. This is because owners are then free to break the implicit contract and fire the manager after a

[19] Unless one introduces randomized punishments; see Joseph Farrell and Maskin (1989).

[20] A (quite straightforward) formal proof of this statement is available from the author upon request.

deviation from a tacit collusive agreement occurs. After they take back control, owners can personally implement any (optimal or renegotiation-proof) punishment available. On the other hand – whatever the punishment phase looks like – short-term delegation maintains its pro-collusive effect linked to the low (zero) gains from deviations obtained by managers under capped incentive contracts.

6 On the secret renegotiation of top-managers' contracts

In Sections 3 and 4 we assumed observable and binding managerial incentive contracts, as in most previous work on strategic delegation in oligopoly. While observability is more and more a characteristic of top managers' compensation,[21] Mathias Dewatripont (1988), Katz (1991), and others pointed out that the credibility of commitments through contracts with third parties can be undermined by agents' ability to *secretly* renegotiate the contracts. Unfortunately, this correct argument has been sometimes improperly used to cast doubts on the overall relevance of the literature on strategic delegation. It is therefore time to make clear that managerial contracts have no commitment value only in the extreme case where secret renegotiation is both *feasible* and *costless.* If secret renegotiation is feasible but costly, the commitment value of observable contracts is positive and proportional to renegotiation costs. And the case of secretly and costlessly renegotiable managerial contracts may be an interesting one from a theoretical point of view or, at best, as a benchmark. In reality, a bunch of established institutions make the secret renegotiation of top-managers' incentive contracts either unfeasible or, when feasible, extremely costly.

While reading the discussion below, the reader should keep in mind that each of the factors discussed is sufficient *alone* to give commitment value to managerial contracts. Also, to avoid this paper becoming a book, the arguments are sketched and heuristic; however, the reader will realize that formally modelling of most of them would be straightforward.

6.1 "Internal" factors

6.1.1 The charter

Let us begin by noting that shareholders of public companies can easily make the secret renegotiation of their managers' contracts impossible. They can have a simple rule in the company's charter by which changes of top managers' compensation must be approved by shareholders. Consider our simple model of Sections 3 and 4 and let firm owners free

[21] It is also considered the best practice. For example, the Code of Best Practice of the celebrated Cadbury Report (1992), with regard to executives' compensation states: "There should be full and clear disclosure of [executive] directors' total emoluments [...] including pension, contribution and stock options. Separate figures should be given for salary and performance-related elements and the basis on which performance is measured should be explained."

to secretly renegotiate contracts with their managers. Further, let us adopt the extreme assumption that there are neither exogenous nor intrinsic costs of renegotiation. Still, we can state what follows.

Proposition 11 *Suppose secret contract renegotiation is both feasible and costless. If firms introduce a rule in their charters that requires changes of CEOs' compensation to be approved by shareholders, all previous results apply unchanged.*

A formal proof is not needed, the logic behind the proposition being straightforward. In our model the only reason for shareholders to renegotiate the manager's contract or the rule in the charter that makes such renegotiation public (shareholders' meetings are approximately public events) is to induce a deviation from the collusive agrement. Therefore, as soon as any renegotiation (of the managerial contract or of the rule in the charter) is observed, other firms' managers anticipate a deviation and react optimally by immediately abandoning the collusive agreement. Since this reaction occurs in the same period when the deviation induced by renegotiation does, no short-run gain can be obtained by renegotiating and the statement follows.

6.1.2 The board of directors

In most real world public companies not all changes of top managers' compensation are subject to shareholders' approval. CEO compensation is usually in the hands of the "compensation committee" of the board of directors, within the (often restrictive) limits set by shareholders. These limits cannot be secretly renegotiated, as they are set and can be modified only during public shareholders' meetings, but sometimes boards are left with sufficient freedom to induce a CEO to break a cartel by secretly renegotiating his incentives, if desired. It turns out, though, that boards themselves usually discount extreme performance realizations from managers' compensation, making it "capped" (Joskow and Rose, 1994). So the question is: Why do boards give managers the kind of low-powered incentives that lead to income smoothing and collusive behavior? The first, obvious answer that comes to mind is that this is what boards want. That is, boards of directors leave top managers with such low-powered incentives because directors themselves have these kinds of incentives. In fact, directors tipically enjoy firm perquisites and have generous compensation with even more low-powered incentives than managers, so they are also interested in a continuous flow of "satisfactory" (collusive) profits that ensures reappointment (future incumbency rents).[22] This means that *all what we have written in the previous sections*

[22]This is also considered the best practice. Again, the Code of Best Practice of the Cadbury Report (1992) states: "The Committee regards it as good practice for non-executive directors not to participate in share option schemes and for their service as non-executive directors not to be pensionable by the company, in order to safeguard their independent position."

can be restated after replacing the word "managers" with the word "directors." And directors' compensation must be renegotiated or renewed in public shareholders' meetings, it cannot be *secretly* renegotiated, so Proposition 11 applies.

In other words, if shareholders choose "conservative" incentives for directors – as they usually do – and these lead directors to choose the observed "conservative" incentives for CEOs, then firms are fully and credibly committed to "conservative" (collusive) product-market strategies even when secret renegotiation is feasible and costless.

6.2 External factors: directors' "information network"

6.2.1 Directly interlocking directorates (discuss Laffont and Meleu, 1997)

Kevin Hallock (1997) finds that 20 to 30% of U.S. firms have directly interlocked boards of directors, in the sense that they have a manager or a director sitting on each other's board. One would expect directly interlocking directorships between competing firms to be forbidden, as it is all too obvious that they can soften competition, for example by facilitating information sharing and coordination. However, the U.S. is the only country we are aware of where interlocking directorships between competing firms are forbidden.[23] In most other countries, both advanced and less developed, directly interlocking directorships between competitors are not forbitten, and are in fact quite common.[24]

To make the point in the simplest way, let us consider a duopoly with directly interlocking directorships. A duopoly where, say, an executive director of each firm serves as outside director in the other firm. Since to renegotiate the CEO's contract at least a meeting of the compensation commettee is required, and since such committees are normally composed of outside directors,[25] each interlocked director will know per time of any renegotiation attempt, and can veto it by threatening to reveal it to the CEO of the firm of which he is executive (who would react and nullify all gains from renegotiation, as argued for Proposition 11; if the interlocked director is the CEO himself, this threat is particularly credible). Of course, the silence of the interlocked director could be bought, but the price would be high: the interlocked director must be compensated for the loss of his job, the

[23] They were forbidden in the early 1900, thanks to the efforts of Louis Brandeis. See Miguel Cantillo Simon (1998) for a recent account of how this prohibition – together with the others in the Clayton and Glass-Steagall Acts – came about in the US.

[24] Just to make an example, Giovanni Ferri and Sandro Trento (1997) find that directly interlocking directorships between large banks are very common in Italy. They give the example of Ugo Tabanelli, director and vice-chairman of Banco di Santo Spirito between 1960 and 1985, who in the same period was simultaneously sitting on the boards of 4 of its main competitors: Banca di Roma, Credit, Comit, and Mediobanca.

[25] Again, this is considered the best practice. Once more, the Code of Best Practice of the Cadbury Report (1992) states: "Executive directors' pay should be subject to the recommendation of a remuneration committee made up wholly or mainly of non-executive directors."

loss of reputation, and the other career concerns of a top executive that "betrays" his firm (in principle, the betraying executive could even be sued by shareholders for violation of "fiduciary duties").[26]

6.2.2 Indirectly interlocking directorates

La Porta et al. (1998) find pyramidal ownership to be the most common mechanism by which controlling shareholders of large companies separate (and sell) cash flow rights and control rights around the world. Of the 75% of the companies in their cross-country top-twenty sample that have a dominant shareholder, 26% belong to a pyramidal structure.

Consider again a duopoly, and suppose the two firms are controlled through pyramids. Suppose, further, that the CEO (or another top executive) of any firm at a higher stage of each pyramid serves as outside director in the board of the duopolistic firm controlled by the other pyramid. We define these outside directors as indirectly interlocked ones. An example of the situation is represented in Figure 1.

Place Figure 1 About Here

CEOs (and other executives) of firms within a pyramid are all accountable to the same controlling shareholder, who would not be happy to see his controlled duopolist cheated upon by its rival. Therefore, the indirectly interlocked outside directors would also block any secret renegotiation of the CEO contract that could lead to a breach of collusion, again, by threatening to reveal it to the other duopolistic firm, the one that belongs to the same pyramid as the firm where they serve as CEO.

The silence of the indirectly interlocked director could also be bought, but the price would be high, as for directly interlocked directors. And controlling shareholders can further raise this price by choosing for delicate tasks such as that of indirectly interlocking director an especially reliable (very highly paid, or family related) agent.

6.2.3 Common outside directors

Suppose competing firms have one or more outside directors in common (for example, a non-executive director who has an especially good knowledge of the industry). We wrote that outside directors normally enjoy generous perquisites and (flat) fees from firms, so the objective of common directors will be a satisfactory (e.g. collusive) profitability of both firms that ensures reappointment. Common outside directors can also veto the secret renegotiation of top manager's contract by threatening to make it public. Therefore,

[26] To prevent renegotiation the interlocking directors can be chosen among the executives with more to lose from betraying the firm, they can be the CEO themselves. However large the cost of buying interlocked directors is, as long as they are positive they give commitment power to managerial incentives.

they must also be fully compensated for the losses they may incur (fees, private benefits, reputation) because of the non-deviating firm's bad performance. The extra costs of renegotiation linked to common directors' partial internalization of competing firms' market externalities further reinforces the commitment value of managers'/directors' incentives.

6.2.4 Common stakeholders

In many countries it is common to let stakeholders have seats on the board of directors. For example, in Germany's co-determination system (mitbestimmung) workers' unions have directors on firms' supervisory boards, which have control on executives' compensation. Unions are organized by industry, so that the same union ends up having directors on the supervisory boards of firms in the same industry. As long as workers enjoy a share of their firm's collusive rent, as it is natural to assume, the industry union internalizes market externalities between firms. Then union's directors will oppose any managerial contract secret renegotiation that may lead to a breach of collusion, with the consequent reduction of the industrywide collusive rent. The same holds for other common stakeholders, such as debtholders (e.g. large banks) that are lending to more firms in the industry and have directors on their boards.

6.3 Other examples of renegotiation costs

6.3.1 Direct bargaining costs

Even if we assume concentrated ownership, so that public shareholders' meetings are not required to renegotiate directors' compensation, the costs of renegotiation may be substantial for owners. There will typically be direct costs in the bilateral bargaining process between managers and owners, even in the absence of information asymmetries (Luca Anderlini and Leonardo Felli, 1998). And when third parties – such as unions or debtholders – have seats on the board, the bargaining process becomes multilateral and direct renegotiation costs increase substanially (Olivier Compte and Philippe Jeihel, 1996).

6.3.2 The managers' community

A kind of indirect renegotiation cost has to do with the ability of the "top-managers' community" to enforce cooperative behavior between their members. The "top-managers' community," particularly in small countries, is a network whose members interact in various kinds of "cooperative" activities. One is wage-busting. For example, Kevin Hallock (1997) finds that when firms are interlocked managerial compensation goes up. That is, managers treat each other well. Another is unemployment insurance. CEOs fired from a

firm are often hired as managers or directors of competing firms.[27] A breach of a collusive agreement by one manager induced by the secret renegotiation of his contract damages other managers in the industry, and may be punished by the "managers' community" with the interruption of wage-busting and unemployment insurance provisions. The loss of colleagues' support reduces the deviating manager's expected wage after the deviation, so a manager would require compensation for this additional loss at the renegotiation stage.[28]

7 Concluding remarks

Our model showed that most commonly observed managerial compensation practices greatly facilitate collusive behavior in long-run oligopolies. This central result is not only relevant for public companies with dispersed shareholders: ordinary decisions such as pricing and quantity-setting ones are normally in the hands of professional managers also when ownership is concentrated, and even in fully private companies.

Although, for completeness, in Sections 3 and 4 we endogenized owners' choice of managers' incentives, we don't want to push the idea of shareholders rationally choosing pro-collusive managerial incentives too much. In fact, our preferred interpretation of this paper's results is an "evolutionary" one. The idea of fully rational economic agents is nowadays considered a myth by many economists. It is also well known that even though agents are not fully rational, efficient institutions such as "as if" rational behavioral rules may be selected by the evolutionary force of competition... or by that of oligopolistic interaction. Consider boundedly rational investors (and consultants) who select directors' and CEOs' incentives on the basis of their past success, in a world dominated by oligopolistic industries. Such investors would not be aware of exactly why choosing "conservative" or "prudent" incentives for managers pays more in the long run than choosing aggressive incentives, and will be even less aware that secretly renegotiating incentive contracts might pay even more. We speculate that in the many supergames they have played over time, investors have tried different incentives for top managers, and that because of

[27] One reason for this is, of course, the inside knowledge about the competitor that the fired manager brings along. Another reason, however, is the "mutual non-market insurance" against unemployment which the managers' community provides for its members.

[28] The effect of the loss of reputation within the managers' community is stronger the shorter the length of managers' contracts is. In the case of short-term contracts the manager can be fired – and therefore suffers the reservation wage loss right from the period after the deviation. With long-term contracts the owner is committed to keeping the manager at the pre-deviation reservation wage, so that unemployment insurance is less valuable to managers. However, even very long-term contracts are normally of limited length compared to the length of a manager's career. Bankruptcy, takeovers, and other unforeseen events may interrupt the long-term contract between an owner and the manager, in which case colleagues' support becomes important. Knowing this, the manager will always require extra compensation to "betray" his colleagues.

the oligopolistic structure of most real world industries the "conservative" low-powered incentives observed by Jensen and Murphy are those that performed better and survived.[29]

Finally, we are not arguing here that firms' attempts to internalize market externalities is the only force that drives real world economic institutions. For example, as in most previous work on the strategic effects of delegation, we had to abstract from the important issue of managerial moral hazard (just as most of the literature on moral hazard abstracts from the strategic effects of incentive contracts). When moral hazard is brought into the picture, a demand for highly-powered incentives emerges and too low-powered incentives become suboptimal. However, the pro-collusive effect we identified is very strong, which makes it difficult not to think of it as one important reason why puzzling governance practices such as low-powered managerial incentives and tolerance for income smoothing are so widespread in our world.[30]

[29]Managers in our delegation supergame can be seen as automata chosen by owners/players in a "metagame" to play a subsequent supergame, as in the work of Abreu and Rubinstein (1988). Under such interpretation the capped incentive schemes discussed in Sections 3 and 4 would correspond to automata instructed not to deviate first, to play "nice" strategies, but also to fight "nasty" automatas (managers with high-powered incentives). The work of Robert Axelrod (1984) and of many others after him has shown that in the repeated Prisoner's Dilemma, which is isomorphic to repeated oligopoly games, even simpler automata with nice strategies tend generally to survive.

[30]True, Brian Hall and Jeffrey Liebmann (1998) have documented that the widespread adoption of stock-related incentive plans has substantially increased U.S. top managers' pay-performance sensitivity in the last fifteen years. However, these highly-powered stock-related incentives also appear to be usually designed so that they facilitate tacit collusion in product markets (Spagnolo, forthcoming).

8 Appendix

Proof of Proposition 1 To prove the proposition we must show that when – because of managerial control – firms' instantaneous objective function is subject to any strictly concave monotone transformation $U(\pi_i)$ of the profit function $\pi_i(p) = \frac{1}{N}(p-c)Q(p)$, the incentive constraints to support any collusive agreements are relaxed. We first need a simple lemma.

Lemma 3 *The Bertrand equilibrium remains the unique static Nash equilibrium of the stage game when this is played by agents with a strictly concave objective function.*

Proof A strictly concave objective function is a monotone transformation of the profit function. The set of Nash equilibria of a game is not affected by monotone transformations of payoff functions, as these generate ordinally equivalent games. **Q.E.D.**

The lemma makes sure that reversion to the static Bertrand equilibrium remains a credible punishment strategy when managers are running the firms. Now, for any strictly concave increasing objective function $U(\pi_i)$, $U' > 0$, $U'' < 0$, a stationary collusive agreement on price p^* will be supported by firm i if

$$\frac{1}{1-\delta}U[\frac{1}{N}(p^*-c)Q(p^*)] \geq U[(p^*-c)Q(p^*)] + \frac{\delta}{1-\delta}U(0),$$

or, equivalently, if

$$\delta \geq \frac{U[(p^*-c)Q(p^*)] - U[\frac{1}{N}(p^*-c)Q(p^*)]}{U[(p^*-c)Q(p^*)] - U(0)}. \tag{A.1}$$

The concave transformation will always make collusion easier to sustain if the RHS of condition (A.1) is smaller than the RHS of condition (1), i.e. when

$$\frac{U[(p^*-c)Q(p^*)] - U[\frac{1}{N}(p^*-c)Q(p^*)]}{U[(p^*-c)Q(p^*)] - U(0)} < (1-\frac{1}{N}).$$

After a few algebraic manipulations this last inequality leads to

$$U[\frac{1}{N}(p^*-c)Q(p^*)] > U(0) - \frac{1}{N}U(0) + \frac{1}{N}U[(p^*-c)Q(p^*)],$$

and then to

$$U[\frac{1}{N}(p^*-c)Q(p^*) + (1-\frac{1}{N})0] > \frac{1}{N}U[(p^*-c)Q(p^*)] + (1-\frac{1}{N})U(0),$$

which is Jensen's inequality, the definition of strict concavity, property assumed for U. **Q.E.D.**

Proof of Proposition 2 Demand is now an increasing function of the stochastic shock θ, $Q(p,\theta)$. When profit-maximizing owners run the firms, the no-deviation conditions for a collusive agreement to choose a price p^* are

$$\frac{1}{N}(p^*-c)Q(p^*,\theta^H) + \frac{\delta}{1-\delta}\frac{1}{N}(p^*-c)E_\theta\ [Q(p^*,\theta)] \geq (p^*-c)Q(p^*,\theta^H)$$

in periods in which demand is high, and

$$\frac{1}{N}(p^*-c)Q(p^*,\theta^L)+\frac{\delta}{1-\delta}\frac{1}{N}(p^*-c)E_\theta\ [Q(p^*,\theta)]\geq(p^*-c)Q(p^*,\theta^L)$$

in periods in which demand is low, where E is the expectation operator. The conditions can be rewritten as

$$\begin{cases}(1-\frac{1}{N})(p^*-c)Q(p^*,\theta^H)\leq\Pi\\(1-\frac{1}{N})(p^*-c)Q(p^*,\theta^L)\leq\Pi\end{cases},$$

where $\Pi=\frac{\delta}{1-\delta}\frac{1}{N}(p^*-c)E_\theta\ [Q(p^*,\theta)]$. Given that the two conditions differ only in the demand factors on the LHS, and that $Q(p^*,\theta^H)>Q(p^*,\theta^L)$, the condition is more easily satisfied in low states of demand, and when the discount factor is binding and firms maximize collusive profits, Rotemberg and Saloner's result follows.

Consider instead firms led by income-smoothing managers, with static objective function $U(\pi_i)$, $U'()>0, U''()<0$. The conditions now become

$$\begin{cases}U\left[(p^*-c)Q(p^*,\theta^H)\right]-U\left[\frac{1}{N}(p^*-c)Q(p^*,\theta^H)\right]\leq\Pi^U\\U\left[(p^*-c)Q(p^*,\theta^L)\right]-U\left[\frac{1}{N}(p^*-c)Q(p^*,\theta^L)\right]\leq\Pi^U\end{cases},$$

where $\Pi^U=\frac{\delta}{1-\delta}E_\theta\ \left[U\left[\frac{1}{N}(p^*-c)Q(p^*,\theta)\right]\right]$. When the discount factor is binding and firms maximize collusive profits, price wars during booms do not occur and prices are pro-cyclical when

$$U\left[(p^*-c)Q(p^*,\theta^H)\right]-U\left[\frac{1}{N}(p^*-c)Q(p^*,\theta^H)\right]<$$

$$<U\left[(p^*-c)Q(p^*,\theta^L)\right]-U\left[\frac{1}{N}(p^*-c)Q(p^*,\theta^L)\right]$$

or, equivalently, when

$$U\left[\pi_i^*(\theta^H)\right]-U\left[\pi_i^*(\theta^L)\right]>U\left[N\pi_i^*(\theta^H)\right]-U\left[N\pi_i^*(\theta^L)\right].$$

If we approximate the RHS of this inequality with the Taylor expansion of U around $N\pi_i^*(\theta^L)$ and simplify, we get

$$U\left[\pi_i^*(\theta^H)\right]-U\left[\pi_i^*(\theta^L)\right]>U'\left[N\pi_i^*(\theta^L)\right]N\left[\pi_i^*(\theta^H)-\pi_i^*(\theta^L)\right]-\Delta,$$

with $\Delta>0$. By inspection, U can always be chosen concave enough to make $U'\left[N\pi_i^*(\theta^L)\right]<\frac{U\left[\pi_i^*(\theta^H)\right]-U\left[\pi_i^*(\theta^L)\right]+\Delta}{N\left[\pi_i^*(\theta^H)-\pi_i^*(\theta^L)\right]}$ and satisfy the inequality. **Q.E.D.**

Proof of Lemma 1 Suppose owner i chooses $B_i,\pi_i^B,\gamma_i>0$. Then, if the manager of firm i respects a collusive agreement delivering per-period profits $\pi_i^*\geq\pi_i^B$ he receives the discounted future income flow $\frac{\gamma_i g_i(\pi_i^*)+B_i}{1-\delta}$, while if he deviates he obtains $\gamma_i g_i(\widehat{\pi}_i^*)+B_i$

immediately and zero afterwards. It follows that the manager will respect the collusive agreement if

$$\frac{\gamma_i g_i(\pi_i^*) + B_i}{1-\delta} \geq \gamma_i g_i(\widehat{\pi}_i^*) + B_i, \;\; \Leftrightarrow \;\; \delta \geq \delta^\gamma \; = \frac{\gamma_i \left[g_i(\widehat{\pi}_i^*) - g_i(\pi_i^*)\right]}{\gamma_i g_i(\widehat{\pi}_i^*) + B_i}.$$

By inspection, when $\gamma_i > 0$, δ^γ is positive and increasing in γ_i. When an owner chooses $B_i, \pi_i^B, \beta_i > 0$, and managers are restricted to choosing $p \geq c$, the static Nash equilibrium of the market game is unchanged and the manager of firm i respects a collusive agreement delivering per-period profits π_i^* if

$$\frac{\beta_i f_i(\frac{p^* Q(p^*)}{N}) + B_i}{1-\delta} \geq \beta_i f_i(cQ(p=c)) + B_i + \frac{\delta \beta_i f_i(\frac{cQ(p=c)}{N})}{1-\delta},$$

or, equivalently, if

$$\delta \geq \delta^\beta \; = \frac{\beta_i \left[f_i(cQ(p=c)) - f_i(\frac{p^* Q(p^*)}{N})\right]}{\beta_i \left[f_i(cQ(p=c)) - f_i(\frac{cQ(p=c)}{N})\right] + B_i}.$$

Again, by inspection, when $\beta_i > 0$ the minimum discount factor δ^β is positive and increasing in β_i. When an owner chooses both $\gamma_i, \beta_i > 0$ these two effects cumulate and the pro-collusive effect of the bonus is further diluted. The statement follows from this together with Proposition 3. **Q.E.D.**

Proof of Proposition 5. Suppose the realization of θ can be observed by owners with T^O periods of delay, and by courts with T^C periods of delay, where $T^C \geq T^O$ (when θ is the report of an independent agency, T^C is the lag with which the reports are made). Consider the following compensation contract: in each period the manager gets a wage plus a bonus $B_i > 0$ if $\pi_i(\theta) \geq \pi_i^B(\theta)$, but the bonus is paid to the manager with T^C periods of delay and increased market interests to compensate for it. If owners break the contract managers can go to court $T^C - T^O$ periods afterwards and be compensated (therefore owners will respect the agreement). Then the rest of the proof is identical to that of Proposition 3, after having replaced π_i^B by $\pi_i^B(\theta)$, π_i^* by $\pi_i^*(\theta)$, $\widehat{\pi}_i^*$ by $\widehat{\pi}_i^*(\theta)$, π_i^M by $\pi_i^M(\theta)$, $\widehat{\pi}_i^M$ by $\widehat{\pi}_i^M(\theta)$, and interpreting B_i as the present value of the payment obtained T^C periods later. **Q.E.D.**

Proof of Proposition 6 (i) Consider first the second stage. Suppose all managers have been hired under bonus contracts, with $B > 0$ and $\pi_i^B = \pi_i^M(\theta^H)$. Then by the proof of Proposition 3 follows that whatever the discount factor is, managers can support any price rule $\pi_i^*(\theta)$ such that $\pi_i^*(\theta^H) = \pi_i^M(\theta^H)$ and $\widehat{\pi}_i^*(\theta^L) < \pi_i^M(\theta^H)$. This is because in equilibrium managers receive bonuses in all high states, while a deviating manager gains nothing in the period of the deviation, but looses the stream of future bonuses $\frac{\delta q B}{1-\delta}$. When

the price rule has $\pi_i^*(\theta^L)$ such that $\widehat{\pi}_i^*(\theta^L) \geq \pi_i^M(\theta^H)$, a manager gains B by deviating from the joint monopoly price in low states. These kind of unilateral deviations can be deterred only if $B < \frac{\delta q B}{1-\delta} \Leftrightarrow \delta > \frac{1}{1+q}$. It follows that when

$$\widehat{\pi}_i^M(\theta^L) = (p^M - c)Q(p^M, \theta^L) > \frac{(p^M - c)Q(p^M, \theta^H)}{N} = \pi_i^M(\theta^H) = \pi_i^B$$

managers can support the joint monopoly price also in low states of demand only if $\delta > \frac{1}{1+q}$.

Consider now the first stage. An owner can deviate unilaterally from the equilibrium profile by choosing not to delegate control (e.g. setting $B = 0$) or by setting $\pi_i^B \neq \pi_i^M(\theta^H)$. In the first case no collusive agreement can be supported in the second stage, whatever the state of demand is. In the second case, when the owner sets $\pi_i^B > \pi_i^M(\theta^H)$ again no collusive agreement can be supported in the second stage, and when the owner sets $\pi_i^B < \pi_i^M(\theta^H)$ he gains nothing, while he may lose because his manager may settle with a collusive agreement delivering lower profits than $\pi_i^M(\theta^H)$. In all these cases the owner cannot gain by deviating unilaterally.

(ii) Consider first the second stage. Suppose all managers have been hired under bonus contracts, with $B > 0$ and $\pi_i^B = \pi_i^M(\theta^L)$. Then by the proof of Proposition 3 managers can support any collusive agreement A by which in low states firms set the monopoly price so that $\pi_i^A(\theta^L) = \pi_i^M(\theta^L)$, and in high states set any price such that $\pi_i^A(\theta^H) \geq \pi_i^M(\theta^L)$. The exact collusive price that managers will support in high states depends then on φ.

Consider now the first stage, and let us check whether $\pi_i^B = \pi_i^M(\theta^L)$ is a Nash equilibrium for owners. The best that an owner can do when deviating from such a strategy profile, is setting $\pi_i^B = (p^M - c)Q(p^M, \theta^H) - \frac{N-1}{N}(p^M - c)Q(p^M, \theta^L)$, so that in low profit states collusion cannot be supported but in high states it is, and the only agreement the manager of the deviating owners will set for delivers to the deviating owners per-period profits $(p^M - c)Q(p^M, \theta^H) - \frac{N-1}{N}(p^M - c)Q(p^M, \theta^L)$, where

$$(p^M - c)Q(p^M, \theta^H) - \frac{N-1}{N}(p^M - c)Q(p^M, \theta^L) > \frac{(p^M - c)Q(p^M, \theta^H)}{N} > \frac{(p^M - c)Q(p^M, \theta^L)}{N}.$$

If this deviation is not profitable, no other deviation is. This unilateral deviation is profitable if

$$\frac{q\left[N\pi_i^M(\theta^H) - (N-1)\pi_i^M(\theta^L)\right]}{1-\delta} > \frac{q\varphi\pi_i^M(\theta^H) + (1-q)\pi_i^M(\theta^L)}{1-\delta}$$

or, equivalently, if

$$\varphi < \frac{q\left[N\pi_i^M(\theta^H) - (N-1)\pi_i^M(\theta^L)\right] - (1-q)\pi_i^M(\theta^L)}{q\pi_i^M(\theta^H)}.$$

When $\frac{1-q}{q} > \frac{(N-1)\left[(p^M-c)Q(p^M,\theta^H) - (p^M-c)Q(p^M,\theta^L)\right]}{(p^M-c)Q(p^M,\theta^L)}$ the RHS of this inequality is smaller than one. Then, for any φ such that

$$1 \geq \varphi \geq \widetilde{\varphi} = \frac{q\left[N\pi_i^M(\theta^H) - (N-1)\pi_i^M(\theta^L)\right] - (1-q)\pi_i^M(\theta^L)}{q\pi_i^M(\theta^H)}$$

the owners' deviation is not profitable and all owners setting $\pi_i^B = \pi_i^M(\theta^H)$ is a Nash equilibrium of the first stage game between owners. Furthermore, as long as $1 > \varphi \geq \widetilde{\varphi}$ managers can support collusion in all states, but they can support the monopoly price only in low states. The statement follows. **Q.E.D.**

Proof of Proposition 7 Consider the following strategy profile for N owners and N managers.

Each owner's strategy: "Delegate to a manager under short-term bonus contract with total compensation above his reservation wage and $\pi_i^B = \pi_i^M$; in Step 1 of each following period reconfirm manager and contract for one more period if in all previous periods all owners delegated and $\pi_i \geq \pi_i^B$; take back control or hire a profit-maximizing manager at his reservation wage forever otherwise."

Each manager's strategy: "In Step 2 of each period t, stick to any agreed collusive price delivering per-period profits $\pi_i \geq \pi_i^B$ for every firm i if *(*a*)* all owners delegated in Step 1 of all past periods and in t, and if (b) no manager ever deviated from the agreed collusive price; maximize firm profits otherwise."

To save on notation, set $W_i = R$ so that the bonus $B_i > 0$ also denotes the amount of collusive rent left to the manager (the relative sizes of W_i and B_i are strategically irrelevant), and consider the joint monopoly price p^M delivering per-period profits $\pi_i^M = \pi_i^B$ to each firm i. Let us check for unilateral deviations in any period t.

Owners: If an owner sticks to equilibrium strategies he expects net profits $\frac{\pi_i^M - B_i}{1-\delta}$, which are always positive (to satisfy his individual rationality constraint he must have set $B_i \leq \pi_i^B \leq \pi_i^M$). An owner can deviate in Step 1 by choosing $\pi^B > \pi^M$, $\pi^B < \pi^M$, by hiring a profit-maximizing manager (e.g. setting $B = 0$), or (equivalently) by not delegating control. If an owner deviates by choosing $\pi_i^B < \pi_i^M$ he cannot gain, but he can lose since even though managers can support collusion in the second stage, his manager may settle with a collusive agreement delivering profits π_i^* with $\pi_i^B \leq \pi_i^* < \pi_i^M$. If an owner deviates by choosing $\pi_i^B > \pi_i^M$, the only way the manager can get the bonus is by deviating unilaterally from a collusive agreement, and because this is common knowledge no agreement can be sustained. When an owner deviates by retaining control or hiring a profit-maximizing manager, he or his manager deviates in Step 2 because condition (1) is not satisfied. However he deviates in Step 1, other players learn that in Step 2 he (or his manager) will deviate from the collusive agreement, so that in the period of the deviation all managers maximize profits and the Bertrand outcome occurs. Because we always have $\frac{\pi_i^M - B_i}{1-\delta} \geq 0$, no owner will find it convenient to deviate unilaterally, whatever the discount rate is.

Managers: As for long-term contracts, if a manager deviates he gains nothing, but he loses the stream of future bonuses $\frac{B_i}{1-\delta}$. It follows that as long as $B_i > 0$ managers will not deviate unilaterally, whatever the discount rate is. **Q.E.D.**

Proof of Proposition 8 The proof is analogous to the proof of Proposition 7 above, after reinterpreting variables by letting B_i denote a manager's private benefits of control and π_i^B the cut-off level of profit below which the manager is replaced. The only (strategically irrelevant) difference is – when checking for unilateral deviations on the side of the managers – that here when a manager deviates he loses the stream of future bonuses $\frac{\delta B_i}{1-\delta}$ instead of $\frac{B_i}{1-\delta}$, as the deviating manager is retained – and enjoys private benefits – for one more period after the deviation occurs. **Q.E.D.**

Proof of Lemma 2 For the case of a short-term bonus contract the proof is identical to the proof of Lemma 1. Consider instead the case of incumbency rents with replacement rules. Suppose the equilibrium selected by owners and supported by the equilibrium strategy profile described in the proof of Proposition 7 has ($W_i = R = 0$ and) $B_i, \pi_i^B, \gamma_i > 0$. Then, if the manager of a firm i respects a collusive agreement delivering per-period profits $\pi_i^* \geq \pi_i^B$ he receives the discounted future income flow $\frac{\gamma_i g_i(\pi_i^*)+B_i}{1-\delta}$, while if he deviates he obtains $\gamma_i g_i(\widehat{\pi}_i^*)+B_i$ immediately, B_i the next period ($\widehat{\pi}_i^* > \pi_i^* \geq \pi_i^B$, therefore the manager is reappointed for one more period after the deviation), and zero afterwards. It follows that the manager will respect the collusive agreement if

$$\frac{\gamma_i g_i(\pi_i^*) + B_i}{1-\delta} \geq \gamma_i g_i(\widehat{\pi}_i^*) + B_i + \delta B_i \;\Leftrightarrow\; \delta \geq \frac{\gamma_i \left[g_i(\widehat{\pi}_i^*) - g_i(\pi_i^*)\right]}{\gamma_i g_i(\widehat{\pi}_i^*) + \delta B_i}.$$

As in the proof of Lemma 1, for $\gamma_i > 0$ the RHS is positive and increasing in γ_i, as when differentiating the RHS and rearranging we obtain

$$\frac{\partial RHS}{\partial \gamma_i} = \frac{\left[g_i(\widehat{\pi}_i^*) - g_i(\pi_i^*)\right] \delta B_i}{\left[\gamma_i g_i(\widehat{\pi}_i^*) + \delta B_i\right]^2} > 0.$$

When an owner chooses $B_i, \pi_i^B, \beta_i > 0$, his manager respects a collusive agreement delivering per-period profits π_i^* if

$$\frac{\beta_i f_i(\frac{p^* Q(p^*)}{N}) + B_i}{1-\delta} \geq \beta_i f_i(cQ(p=c)) + B_i + \delta B_i,$$

or, equivalently, if

$$\delta \geq \frac{\beta_i \left[f_i(cQ(c)) - f_i(\frac{p^* Q(p^*)}{N})\right]}{\beta_i f_i(cQ(c)) + \delta B_i}.$$

When $\beta_i > 0$ the RHS of this inequality is positive and increasing in β_i. Again, when (at least) one owner chooses both $\gamma_i, \beta_i > 0$, these two effects cumulate and the pro-collusive effect of private benefits is further diluted. The statement follows from this together with Proposition 8. **Q.E.D.**

Proof of Proposition 10: With long-term contracts in the second-stage market supergame, managers under the mixed incentive contract sustain the joint monopoly col-

lusive agreement if

$$\frac{\rho_i\left(\alpha_i^{FJS}\pi_i^M+(1-\alpha_i^{FJS})S_i(q_i^M)\right)+(1-\rho_i)B}{1-\delta}\geq\rho_i\left(\alpha_i^{FJS}\widehat{\pi}_i^M+(1-\alpha_i^{FJS})S_i(\widehat{q}_i(q_{-i}^M))\right)+$$

$$+(1-\rho_i)B+\frac{\delta}{1-\delta}\left[\rho_i\left(\alpha_i^{FJS}\pi_i^{FJS}+(1-\alpha_i^{FJS})S_i^{FJS}\right)\right],$$

which reduces to

$$\delta\frac{(1-\rho_i)B}{1-\delta}\geq\rho_i\left(\alpha_i^{FJS}\widehat{\pi}_i^M+(1-\alpha_i^{FJS})S_i(\widehat{q}_i(q_{-i}^M))\right)-\rho_i\left(\alpha_i^{FJS}\pi_i^M+(1-\alpha_i^{FJS})S_i(q_i^M)\right).$$

By inspection, for any $\left(\alpha_i\widehat{\pi}_i^M+(1-\alpha_i)S_i(\widehat{q}_i(q_{-i}^M))\right)-\left(\alpha_i\pi_i^M+(1-\alpha_i)S_i(q_i^M)\right)$ and for any δ there is a level $\underline{\rho}$ such that when $\rho_i,\rho_j\leq\underline{\rho}$ the incentive constraint is satisfied and managers sustain the joint monopoly collusive agreement.

Consider now the first-stage delegation game among owners, and let us check whether the mixed contract is an equilibrium strategy. If both owners choose the prescribed mixed contracts, managers sustain collusion and owners share monopoly profits. If owner i deviates by choosing a managerial contract that leads manager i to deviate from the collusive agreement (that is, chooses $\rho_i>\underline{\rho}$) manager j observes the choice, realizes that whatever he does he will never get his bonus (or that he will be replaced anyway) and maximizes the FJS-type part of his compensation $\alpha_j^{FJS}\pi_j+(1-\alpha_j^{FJS})S_j$ only. This leads both managers to maximize the FJS part objective function in the second stage, so both firms obtain $\pi_i^{FJS}=\pi_j^{FJS}$ in the period of the deviation. It follows that deviating is not profitable, and that even when owner i deviates by choosing parameters that lead manager i to deviate, sticking to the equilibrium contract is an optimal strategy for owner j. If owner i deviates by choosing a managerial contract that does not lead to a deviation (for example chooses $\rho_i=0$) collusion is sustained and owner j still loses nothing by sticking to the equilibrium contract.

The case of short-term contract is analogous. When collusion is supported by the strategy profile described in the proof of Proposition 7, each owner cannot gain by unilaterally deviating from delegating control to the manager under a short-term mixed incentive contract. And such a contract allows the manager to sustain the joint monopoly collusive agreement while protecting the owner from a competing owner's deviation with FJS-type managerial incentives. **Q.E.D.**

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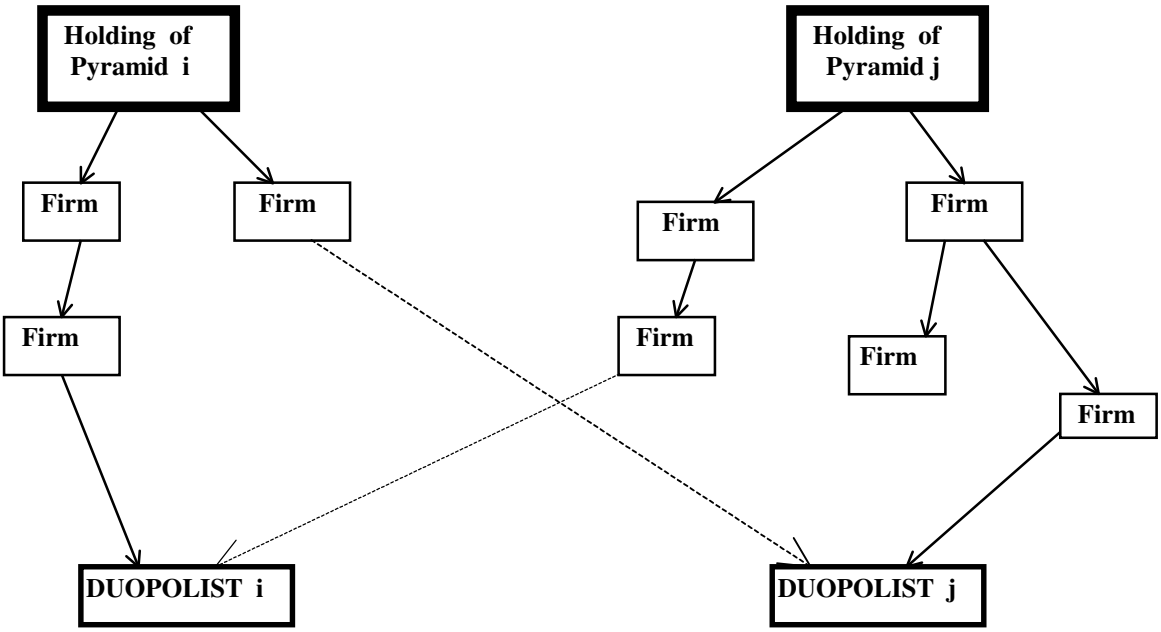

Director

Control

FIGURE 1