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Delegation and Firms' Ability to Collude: Do Incentive Schemes Matter?

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Delegation is widely used by firms. Instead of dealing themselves with production decisions, owners delegate production to managers. If effects of delegation on collusion have been studied previously, the effect of incentive contracts on the sustainability of collusion is unclear. This paper introduces incentive schemes based on relative profits (RP) in the analysis of cartel stability when firms have the option to delegate production decisions to a manager. The approach followed similar to Lambertini and Trombetta (2002), where managerial utility functions prefer to combine profits and sales. When RP contracts are used, collusion between managers ceases to be independent of delegation and collusion between firm owners is harder to sustain. Also, if managers are not able to collude, the relationship between owners' delegation decisions and their discount factor is non-monotonic, but the discontinuity occurs at higher discount factors relatively to what Lambertini and Trombetta found. Since with RP contracts the symmetric incentive solution is just one of a continuum of equilibria, the possibility of reverting to asymmetric incentive equilibrium in the punishment phase is considered. Overall, the results show that managerial incentive schemes do matter in firms' ability to collude and if asymmetric punishments are used, then collusion becomes very likely.

Keywords: strategic delegation, relative performance evaluation, cartel stability

Introduction

The literature on the formation of cartels in oligopolistic markets usually treats firms as entities whose sole objective is to maximize profits. However, modern companies are often characterized by a separation of ownership from control, which implies that managers' interests are not necessarily aligned with those of their shareholders. Furthermore, it is well known that in industries where firms are interdependent, managerial non-profit maximizing behavior may well serve the interests of profit-seeking owners. This paper examines whether strategic delegation affects the likelihood of collusion and whether managerial incentive contracts

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matter for cartel stability.

The strategic delegation literature mainly focuses on the compensation contracts, those owners of competitive firms offer to their managers as well as on the way in which managerial bonus systems affect the outcome of the market game. This literature builds on the seminal works of Vickers (1985), Fershtman and Judd (1987), and Sklivas (1987). Typical strategic delegation models consist of static two-stage games in which owners design managerial contracts and managers play the market game, given their incentive schemes. These models show that, under Cournot competition, delegating control to a manager whose objective function is a linear combination of profits and sales (or revenues) can be beneficial for the company in that it may give rise to Stackelberg leadership. The resulting equilibrium involves all firms that delegate control in order to achieve a dominant position in the market. In other words, firms are better off when their rivals do not delegate, and hence the equilibrium is constituted by a prisoner's dilemma type problem with all firms putting a positive weight on sales.

Lambertini and Trombetta (2002) (LT hereafter) have extended the aforementioned standard model in two directions. First, the delegation decision is explicitly introduced. Second, they analyze strategic delegation in a dynamic framework. They show that delegation has no effect on cartel stability when collusion takes place between managers (the critical discount factor is the same as in a standard Cournot game without delegation), while it may hinder cartel stability when collusion takes place between owners (the critical discount factor is higher than the one in standard non-delegation Cournot game). They also show that if managers are not able to collude in the output levels, i.e., their discount factor is high, then owners' delegation decisions are non-monotonic in their own discount factor.

What is the impact of various managerial bonus systems on the relationship between delegation and firms' ability to collude? Are the results derived by LT robust to different incentive schemes? These are the two main research questions addressed in this paper. To do so, some changes to the payoff function of managers in the analysis of LT have been made. More precisely, while LT consider managerial payoff functions based on profits and sales (PS), this paper employs incentive schemes based instead on relative performance or profits (RP).

The assumption that firms care about their RP has strong intuitive appeal. One reason for this is to safeguard risk-averse managers against common stocks that have an impact on the market as a whole (Holmström, 1982). Another reason is that a firm can improve its equilibrium profits both in absolute and relative terms when operating in a profit-maximizing environment (Vickers, 1985; Salas Fumas, 1992). In fact, when used for strategic reasons, RP is comparable to PS as it allows the owner to push the manager to become more or less aggressive on the output market depending on the weight of the competitors' performance. More specifically, if this weight is negative, the manager has an incentive to increase output as this will reduce the profits of all firms in the market, but the impact on rival firms' profits is expected to be stronger compared with that on his firm's profits. Conversely, if the weights on the rival firms' profits are positive, the manager has an incentive to maximize industry profits, as well as his firm's profits, which results in a lower market output.

If concern for RP makes interactions among rivals more or less competitive in a one-shot game, what does this type of behavior imply for the sustainability of collusion in a dynamic framework? In other words, how does incentive delegation based on RP affect firms' ability to collude and why do its effects differ from those obtained with PS managerial contracts?

When ownership and control are separated from each other, managers are the key players of the collusive game: they take the decision whether to collude or compete and whether to respect collusive agreements or deviate from them. But the delegation contract plays a crucial role in such a game. In fact, the incentive scheme used in the principal-agent problem determines the way in which a firm's owner shifts the manager's reaction function. The traditional incentive scheme based on PS moves the reaction curve inward or outward (Fershtman & Judd, 1987). In contrast, the use of an incentive scheme based on RP allows the owner to change the slope of the manager's reaction curve (Salas Fumas, 1992; Miller & Pazgal, 2002; Vroom, 2006). Therefore, the particular type of the incentive scheme used in strategic delegation is a matter of importance for cartel stability.

Another reason why incentive delegation based on RP may have a different impact on cartel stability is because the equilibrium value of RP is not unique (in a static two-stage delegation game). If a symmetric equilibrium exists, as is the case for the traditional scheme based on PS, it turns out that with managerial contracts based on RP a continuum of asymmetric equilibria also exists (Miller & Pazgal, 2002; Vroom, 2006). In fact, owners' reaction curves superpose and this creates the potential for owners to use more severe punishments by reverting to an asymmetric equilibrium after a defection.

In the relevant literature, Aggarwal and Samwick (1999) empirically examine compensation contracts for managers in the US manufacturing industry, providing evidence of a positive relationship between managerial compensation and industry performance. Their result becomes stronger in a more competitive environment. Along the same lines, Joh (1999), using data on Japanese firms, provides support to the positive link between managerial compensation and industry performance in highly competitive industries. These results suggest that firm owners can reduce product market competition and facilitate a collusive outcome by positively linking managerial compensation to the rival firms' profits. Adopting a more theoretical approach, Lundgren (1996) presents the "relative profits maximizing incentives", according to which firms attempt to maximize the difference between their own profits relative to the other firms' average profits, as a way to set up a zero-sum game among the firms in an industry. He concludes that firms no longer have an incentive to collude, either actually or tacitly, with regard to prices or outputs. In a different context, Matsumura and Matsushima (2008) find a monotonic relationship between the weight of relative profits in the firm's objective function and the stability of collusive behavior. Some of these results are comparable to those obtained in the literature on partial cross-ownership and tacit collusion (Malueg, 1992; Gilo, Moshe, & Spiegel, 2006). However, none of these papers deal with the endogenous weight on relative profits, which is the focus of this study.

In what follows, delegation decisions and managerial payoffs are based on RP in an analysis of cartel stability. The approach developed by LT is followed, where managers' compensation relies on PS instead of RP. When incentive schemes are based on RP, the critical level of the discount factor which makes collusion between managers sustainable is no longer independent of delegation. In fact, a monotonic relationship holds between the weight on RP in managerial payoffs and the stability of managers' collusive behavior. The findings of this paper also indicate that the discount factor at which collusion between owners can take place is higher than the one obtained by LT. In other words, collusion between owners in setting the value of incentives is harder to sustain when managerial payoffs are based on RP instead of PS. Finally, if managers are unable to sustain collusion, i.e., when they face a high discount factor, a non-monotonic relationship holds between owners' delegation decisions and their own discount factor, which is in line with the results of LT. Nevertheless, the discontinuity and hence the sustainability of collusion occurs at higher discount factors.

Since with RP contracts, the symmetric incentive solution is just one of a continuum of equilibria, the possibility for owners to select asymmetric incentive equilibria during the punishment phase is considered. Then collusion between owners in setting (collusive) incentive schemes to managers, though easier to sustain, is still harder to sustain compared to the non-delegation Cournot game.

The paper is organized as follows. Section two introduces the model which relies on a repeated three-stage game with strategic delegation decisions based on relative profits and Cournot competition. Section three deals with different settings, allowing firm owners and/or managers to collude. It also provides the solution of the entire game and compares the results obtained with RP to those taken with PS and considers punishment involving asymmetric RP Nash equilibrium. Section four is conclusion part.

The Model

First, the three-stage game studied in this paper extends the standard two-stage delegation model to explicitly introduce firm owner decisions to delegate control to managers in a Cournot duopoly. The second part of this section consists on defining managerial incentive contracts based on RP. Finally, a supergame based on different actions which collusion can apply to is solved.

The Three-Stage Game

There are two firms, indexed by $i = 1, 2$, and three stages 0, 1, and 2. In stage 0, each firm's owner makes a decision on whether or not to delegate control to the firm's manager. In particular, each owner selects between strategies e or m, and where e means that the owner does not delegate, in which case his firm is entrepreneurial, and where m means that the owner delegates, in which case his firm is managerial.[1] In stage 1, if the firm is managerial, the owner determines the incentive contract to offer to the manager. Then, in stage 2, the manager decides how much to produce. If, on the other hand, the firm is entrepreneurial, it is the owner that makes the output decision in stage 2. Let q_i denote the output of firm i. Market demand is given by $P = 1 - q_1 - q_2$. It is assumed that firms have constant and equal marginal costs of production, which, without loss of generality, are normalized to zero. Then, firm i's (single-period) profit, π_i, is given by:

$$\pi_i = (1 - q_1 - q_2)q_i \qquad i = 1,2 \tag{1}$$

Incentive Contracts Based on Relative Profits

In this model, the incentive contract that owner i offers to manager i is based on RP.[2] More formally, following Salas Fumas (1992), under this type of contract, manager i receives a compensation that is proportional to:

$$M_i = \pi_i + \theta_i \pi_j \tag{2}$$

where θ_i is the RP parameter.[3] Observe that if θ_i is positive (negative), then manager i's compensation increases (decreases) with the rival firm's profit. Therefore, an RP contract with $\theta_i > 0$ ($\theta_i < 0$), makes manager i less (more) aggressive when setting the output quantity as compared to a strict profit maximizer ($\theta_i = 0$). In what follows, the value of θ_i belongs to the interval $[-1, 1]$. The reason is that a manager could otherwise be more concerned with his rival's profits than with the profits of his own firm.

Salas Fumas' model adds a special element to this model, namely, one in which in stage 0 both owners

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1 Basu (1995) was the first to model the owner's decision to hire a manager in incentive delegation models.

2 Note that firms, owners, and managers are denoted by the same indexes i and j.

3 Actually, manager i's compensation function is $A_i + B_i M_i$ where A_i and B_i are constants. Clearly, maximizing $A_i + B_i M_i$ and maximizing M_i are equivalent if the control variable is q_i and $B_i > 0$. Constants A_i and B_i are appropriately selected by the owners such that the total compensation is negligible. However, this paper does not use any assumption about a competitive market for managers.

delegate (m, m). In this case, the subgame coincides exactly with his model. Given the crucial role played by the RP parameter θ_i, the subgame perfect equilibrium is now solved using backward induction.

In stage 2, manager i maximizes:

$$M_i = (1 - q_1 - q_2)q_i + \theta_i(1 - q_1 - q_2)q_j \tag{3}$$

The reaction function of manager i is:

$$R_i(q_j, \theta_i) = \frac{1-(1+\theta_i)q_j}{2} \tag{4}$$

The optimal output level q_i for a fixed pair of weights (θ_i, θ_j) is given by:

$$q_i(\theta_i, \theta_j) = \frac{1-\theta_i}{3-\theta_i-\theta_j-\theta_i\theta_j} \tag{5}$$

Substituting these quantities back into the firms' profit functions yields the following program for owner i:

$$\max_{\theta_i} \pi_i(\theta_i, \theta_j) = \frac{(1-\theta_i)(1-\theta_i\theta_j)}{(3-\theta_i-\theta_j-\theta_i\theta_j)^2} \tag{6}$$

Jointly solving for both owners' programs gives a continuum of optimal incentive contracts, which is:

$$\theta_i^* = \frac{1+\theta_j}{1-3\theta_j}\theta_j \in [-1,0] \tag{7}$$

Observe with Miller and Pazgal (2002) that, in all of those equilibria, total industry output Q and profits Π are the same: $Q = 3/4$ and $\Pi = 3/16$.

It is worth pointing out that the extreme equilibrium $(\theta_i, \theta_j) = (-1,0)$ yields the Stackelberg outcome, with firm i as the leader ($q_i = 1/2$, $\pi_i = 1/8$) and firm j the follower ($q_j = 1/4$, $\pi_j = 1/16$).

In the unique symmetric Nash equilibrium, $\theta_i = -1/3$, $q_i = 3/8$, and $\pi_i = 3/32$ with $i = 1,2$. Hence, equivalent to the case with incentive based on profits and sales, RP leads to a prisoner's dilemma.

The Repeated Game

The following can summarize the timing of the three-stage game:

- Stage 0 (Delegation stage): Owners decide simultaneously whether or not to delegate control to managers.
- Stage 1 (Incentive stage): If firm i is managerial then owner i sets the managerial incentive parameter θ_i (possibly simultaneously with owner j if firm j is managerial as well).
- Stage 2 (Production stage): Agents in control (both owners, both managers or one owner and one manager) simultaneously choose the quantities to produce on the output market.

This three-stage game is repeated an infinite number of times. This creates the potential for collusion in any of the three control variables: the delegation decision, the weight on relative profits in managerial contracts, or the level of quantities on the output market.

Owners and managers discount future payoffs according to discount factors δ^o and δ^m, respectively. Past actions of all players are commonly observed. It is also assumed that there is perfect recall.

In modeling the possibilities of collusion, the standard model consists in which players follow trigger strategies that employ reversion to the static non-cooperative equilibrium forever if either player deviates.

Collusion Analysis

As mentioned before, the supergame allows for collusion in any stage of the three-stage game. This section considers each type of collusion successively, starting with collusion in the market stage and ending with collusion in the delegation stage.

Collusion in the Market Stage

Three possible cases are possible: both owners delegate the output decision to a manager (firms are managerial), when no owner delegates (firms are entrepreneurial) and when only one of the two owners delegate (one firm is managerial, the rival is entrepreneurial).

Collusion Between Managers

Here, both firms are managerial and the owners do not act cooperatively in setting the incentive parameters θ_i and θ_j. In order to simplify the analysis, and following LT, it is assumed that managers will act in a non-cooperative manner if $\theta_i \neq \theta_j$ and ignore side payments.[4]

Before going further, it is important to investigate the case where managers maximize the joint-payoff function $M = M_i + M_j$. With symmetric incentives $\theta_i = \theta_j = \theta$, the joint-payoff $M = (1+\theta)(\pi_i + \pi_j)$ and is maximized for $q_i + q_j = 1/2$. To keep the symmetry of the game, let $q_i = q_j = 1/4$ (each firm produces half of the collusive monopoly output). Replacing these quantities in (3) and simplifying yields the collusive managerial payoff $M_i^C = (1-\theta)/8$.

The next step consists to examine the deviation from the tacit collusion. Assume manager j sticks to the cartel level ($q_j = 1/4$) while manager i maximizes his payoff M_i. Substituting q_j by 1/4 in (4), the optimal output during the deviation phase $q_i = (3-\theta)/8$. The resulting managerial payoff is $M_i^D = (9-\theta^2)/64$.

Finally, consider the non-cooperative outcome. Each manager independently chooses an output so as to maximize his own payoff function. Using θ values for symmetric incentive schemes in (6), $q_i = 1/(3+\theta)$. The resulting managerial payoff is $M_i^N = (1+\theta)^2/(3+\theta)^2$.

The following proposition summarizes.

Proposition 1. Given symmetric incentive schemes θ, tacit collusion between managers is sustainable if and only if $\delta^m \geq \overline{\delta^m}(\theta)$, with:

$$\overline{\delta^m}(\theta) = \frac{M_i^D - M_i^C}{M_i^D - M_i^N} = \frac{(3+\theta)^2}{17+14\theta+\theta^2} \tag{8}$$

furthermore $\overline{\delta^m}(\theta)$ is decreasing in θ.

It clearly appears that delegation with incentive schemes based on RP affects cartel stability. On the one hand, an increase in θ reduces the gain from cheating on a collusive agreement (M_i^D decreases with θ). On the other hand, an increase in θ softens the punishment that would follow cheating (M_i^N increases with θ). The first effect makes collusion more likely while the second makes it less likely. Proposition 1 states that the former effect always dominates the latter.

This result differs from Proposition 1 in LT, where it is shown that incentive delegation based on PS does not affect cartel stability. The reason is that with PS, a shift in the incentive scheme affects all manager payoffs proportionally, while this is no longer true when RP is considered instead.

Note that $\overline{\delta^m}(0) = 9/17$, which stands for the threshold for the Cournot model. This can be explained by the fact that managers are provided with incentives to act as pure profit maximizers. Therefore, because there is a monotonically decreasing relationship between θ and $\overline{\delta^m}(0)$, collusion is harder to sustain under incentive delegation based on RP, as compared to the case where firms are strict profit maximizers, when $\theta < 0$, and it is easier to sustain when $\theta > 0$.

[4] It is easy to show that under asymmetric incentives, if managers decide to collude and maximize joint payoffs, then only one will produce. But in such a case, the producing manager should accept having to share the surplus with the non-producing one. In order to do that, some side payments should be used.

Collusion Between Owners

Here, both firms are entrepreneurial, i.e., the two owners set the quantities on their own and act in a strict profit-maximizing way. This case is technically equivalent to the previous case where both firms are managerial and $\theta_i = \theta_j = 0$. Therefore, owners are able to collude on the output market if and only if $\delta^o \geq 9/17$.

Collusion between One Owner and One Manager

In this case, one firm (i) is entrepreneurial and the other firm (j) is managerial. Consequently, owner i competes on the output market with manager j. This case is technically equivalent to the case where both firms are managerial with $\theta_i = 0$ and $\theta_j \in [-1,1]$. Therefore, if side payments are ruled out, and to be consistent with the assumption that players collude on the output market only with symmetric incentives, collusion is possible only if owner j sets $\theta_j = 0$. However, from (7), if $\theta_i = 0$, then the best response of owner j is $\theta_j = -1$. It is then assumed that no collusion is going to take place between an owner and a manager at the market stage.

Collusion in the Incentive Stage

Consider now the situation where both firms are managerial and collusion takes place between owners in setting incentive parameters, while managers behave non-cooperatively in choosing the output levels.

The cartel solution is when owners choose θ_i in order to maximize joint profits, $\Pi = \pi_i + \pi_j$. Easy calculations show that joint profits are maximized if and only if $\theta_i = \theta_j = 1$. Then collusive profits are $\pi_i^C = 1/8$, which coincide with the individual cartel profits under strict profit-maximizing behavior.

If, say, firm j's owner sticks to the cartel level $\theta_j = 1$, while the owner of firm i deviates along his best reply function (7), $\theta_i = -1$, entailing a profit of $\pi_i^D = 1/4$.

The unique symmetric Nash equilibrium is characterized by incentives $\theta_i = \theta_j = -1/3$ and profits $\pi_i^N(-1/3\,,-1/3) = 3/32$.[5]

The following proposition summarizes the above analysis.

Proposition 2. When managers play non-cooperatively, collusion between owners is sustainable if and only if $\delta^o \geq \overline{\delta^o}$ with:

$$\overline{\delta^o} = \frac{\pi_i^D - \pi_i^C}{\pi_i^D - \pi_i^N(-1/3,-1/3)} = \frac{4}{5} \tag{9}$$

Observely $\overline{\delta^o} > 9/17$. Therefore, when collusion takes place between owners, and managers behave non-cooperatively, collusion is harder to sustain as compared to the case where firms are strict profit-seekers.

In the presence of strategic incentive delegation, the one-shot Nash equilibrium profit decreases (this stabilizes the collusion), while the single-period deviation profit increases (this destabilizes the collusion), and the increase in the latter outweighs the decrease in the former, making the sustainability of collusion less likely.

Proposition 2 is similar to LT's Proposition 2. However, it appears that RP makes the possibility for firms to support monopoly outputs even less likely, as compared to PS. The reason for this is that deviation is more attractive with RP than with PS.

Collusion to Avoid the "Delegation Dilemma"

Here, this section examines what LT call the "delegation dilemma". The situation can be presented as follows. If owners delegate in stage 0, then owners and managers play the Salas Fumas game in stages 1 and 2,

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[5] Section five discusses on asymmetric equilibria.

which produces the following profits: $\pi_i^N(-1/3, -1/3) = 3/32$. Now, if owners choose not to delegate in stage 0, they play non-cooperatively on the product market at stage 2, thus yielding profits equal to $\pi_i^N(0,0) = 1/9$.[6] Finally, if owner i delegates while owner j keeps control in stage 0, then manager i and owner j compete non-cooperatively in stage 2 with respective payoffs $M_i = (1 - q_i - q_j)q_i + \theta_i(1 - q_i - q_j)q_j$ and $\pi_i = (1 - q_i - q_j)q_i$. This yields quantities $q_i = (1 - \theta_i)/(3 - \theta_i)$ and $q_j = 1/(3 - \theta_i)$ and profit $\pi_i = (1 - \theta_i)/(3 - \theta_i)^2$ which owner i maximizes in stage 1, giving an incentive of $\theta_i = -1$ and a profit of $\pi_i^N(0,0) = 1/8$. Therefore, owners are captured in a prisoner's dilemma and cannot avoid delegation in a static framework. However, if the game is repeated an infinite number of times, then:

Proposition 3. Collusion between owners on the "no delegation" decision is sustainable if and only if $\delta^O \geq \widehat{\delta^O}$ with:

$$\widehat{\delta^o} = \frac{\pi_i^N(-1,0) - \pi_i^N(0,0)}{\pi_i^N(-1,0) - \pi_i^N(-1/3, -1/3)} = \frac{4}{9} \tag{10}$$

This stability condition is more difficult to satisfy than the one in LT. In other words, the "no delegation" decision is harder to sustain under an RP regime than under that of PS. Again, this happens because deviation is more attractive with RP than with PS.

Solving the Supergame

Before solving the supergame, a definition in the context of this paper what LT call "patient" managers and "impatient" managers are necessary. If owners are not able to collude on incentive schemes and set the symmetric Nash equilibrium $\theta_i = \theta_j = -1/3$, then managers will collude on the output market if $\delta^m \geq \overline{\delta^m}(-1/3) = 4/7$ and will play non-cooperatively otherwise. Hereafter, managers are "patient" if $\delta^m \geq 4/7$ and "impatient" if $\delta^m < 4/7$.[7]

Now, two tricky situations are examined separately.

Situation 1: $\delta^m < 4/7$ and $\delta^o \geq 4/5$

Here, owners are in a position to obtain cartel profits either by delegating control to "impatient" managers while setting the collusive incentive scheme or by keeping control and choosing the collusive output themselves. The payoffs are summarized in the following matrix.

If both firms are entrepreneurial (e) and owners collude on the output market (C), then $q_i = 1/4$ and $\pi^C(e, e) = 1/8$. If both firms are managerial (m) and owners collude in setting incentives (C), then $\theta_i = 1$, and "impatient" managers while playing à la Cournot-Nash (N) set the monopoly output $q_i = 1/4$ and profits are $\pi^{C,N}(m, m) = 1/8$. Now, if say firm i is managerial (m) and firm j is entrepreneurial (e), owner i sets the Nash incentive (N) $\theta_i = -1$, after which manager i and owner j set Nash quantities (N) $q_i = 1/2$ and $q_j = 1/4$. The resulting profits are $\pi_i^{N,N}(m, e) = 1/8$ and $\pi_j^{N,N}(e, m) = 1/16$.

One can easily check that of the two Nash equilibria $((m, C),(m, C))$ and $((e, C),(e, C))$, only the former does not involve weakly dominated strategies.

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[6] This notation is used because managerial firms with no incentives ($\theta = 0$) behave like entrepreneurial firms, as strict profit maximizers, yielding to Cournot-Nash profits.

[7] In LT, managers are patient if $\delta^m \geq 9/17$ and impatient otherwise. This explains that the critical threshold of managers' discount factor is independent of the weight of sales: in which case, the attempt at colluding on the part of the managers is completely equivalent, in terms of stability, to its counterpart, when firms are strict profit maximizers. This is no longer the case when managerial payoffs are based on relative profits: the equivalence in terms of cartel stability between managerial firms and entrepreneurial firms holds only if the weight on relative profits is set equal to zero.

Table 1

Delegation Decision Subgame When Owners Are Patient and Managers Are Impatient

		Firm j	
		e	m
Firm i	e	$(1/8, 1/8)$	$(1/16, 1/8)$
	m	$(1/8, 1/16)$	$(1/8, 1/8)$

Table 2

Delegation Decision Subgame When Owners and Managers Are Patient

		Firm j	
		e	m
Firm i	e	$(1/8, 1/8)$	$(1/4, 0)$
	m	$(0, 1/4)$	$(1/8, 1/8)$

Situation 2: $\delta^m \geq 4/7$ and $\delta^o \geq 4/5$

Here, owners can obtain cartel profits by colluding or not in setting incentive schemes, simply by delegating control, since managers are "patient". The payoff matrix is as follows.

This situation occurs when, say, owner i colludes (set $\theta_i = 1$) while owner j plays Nash in setting incentives. Then, one can check that owner j sets $\theta_j = -1$, quantities are $q_i = 0$ and $q_j = 1/2$, and profits are $\pi_i = 0$ and $\pi_j = 1/4$.

Here, again, two Nash equilibria $((m, C),(m, C))$ and $((m, N),(m, N))$ exist, and only the second one does not involve weakly dominated strategies.[8]

The following Proposition summarizes all the above discussions and the results presented so far.

Proposition 4

(a) If $\delta^m \geq 4/7$, then owners delegate and play non-cooperatively in setting incentives (m, N), while managers collude on the output market (C). Per period individual profit is $\pi^{\mathrm{N,C}}(\mathrm{m}, \mathrm{m}) = 1/8$.

(b) If $\delta^m < 4/7$ and

- $\delta^{\mathrm{o}} \in [0, 4/9]$, then owners choose to delegate and play non-cooperatively in setting incentives (m, N). Managers play à la Cournot-Nash on the output market (N). Per period individual profit is $\pi^{\mathrm{N,N}}(\mathrm{m}, \mathrm{m}) = 3/32$;
- $\delta^{\mathrm{o}} \in [4/9, 9/17]$, then owners do not delegate and play non-cooperatively on the output market (e, N). Per period individual profit is $\pi^{\mathrm{N}}(\mathrm{e}, \mathrm{e}) = 1/9$;
- $\delta^{\mathrm{o}} \in [9/17, 4/5]$, then owners do not delegate and collude on the output market (e, C). Per period individual profit is $\pi^{\mathrm{C}}(\mathrm{e}, \mathrm{e}) = 1/8$;
- $\delta^{\mathrm{o}} \in [4/5, 1]$, then owners delegate and collude in setting incentives (m, C). Managers play à la Cournot-Nash on the output market (N). Per period individual profit is $\pi^{\mathrm{C,N}}(\mathrm{m}, \mathrm{m}) = 1/8$.

When managers are "impatient" ($\delta^m < 4/7$), then owners' delegation decision is non-monotonic in their discount factor δ^o. This result is in accordance with LT (see Proposition 4). But as one can check, the threshold at which owners cannot avoid the delegation dilemma and the one at which owners are in a position to delegate in order to collude and give "impatient" (non-cooperative) managers the incentives to produce the monopoly output, are smaller with RP than with PS. In other words, collusion at the delegation stage and collusion at the incentive stage are harder to sustain with RP than with PS. These results are explained by the

[8] Intuitively, if managers are going to collude in the market stage, no matter what incentive they face, there is no incentive for owners to collude in the first place.

fact that the deviation profit is higher and the punishment is less severe (the one-shot Nash equilibrium profit is higher) when compensations are based on RP rather than PS.

Punishment Involving Asymmetric Nash Equilibrium

When analyzing collusion between owners, it is assumed that after detecting a deviation by any of them from the collusive equilibrium, both the loyal and the deviant owners reverted to the unique symmetric Nash equilibrium. However, the punishments presented above are not the hardest subgame perfect punishment. It is important to examine the issue of whether selecting an asymmetric Nash equilibrium in the punishment phase constitutes a more severe deterrent to deviation.

First, consider the case where owners delegate and collude on the incentive parameter. Consider this alternative trigger strategy: both owners set the collusive incentive as long as they collude, but if owner i deviates in any period, then owner j will select the asymmetric Nash equilibrium $\left(\theta_i, \theta_j\right) = (0, -1)$ forever. Note that if owner j chooses the weight $\theta_j = -1$ for his manager, then owner i cannot do better than by setting $\theta_i = 0$ in his manager's payoff function.

Recall that owner i deviating optimally from collusive incentive $\theta_i = 1$ will set $\theta_i = -1$ and earn a single-period profit of $\pi_i^D = \pi_i^N(-1,1) = 1/4$. But his one-period profit during the retaliation phase is now $\pi_i^N = \pi_i^N(0,-1) = 1/16$, instead of $\pi_i^N(-1/3, -1/3) = 3/32$. In other words, the deviant owner's per-period profit during the retaliation phase decreases, implying that the punishment imposed after cheating occurs becomes more severe as punishment involves the asymmetric Nash equilibrium rather than the symmetric one. Finally, as per period individual collusive profit is $\pi_i^C = \pi_i^N(1,1) = 1/8$, the critical threshold for owners to sustain collusive incentives turns out to be:

$$\widetilde{\delta^o} = \frac{\pi_i^D - \pi_i^C}{\pi_i^D - \pi_i^N} = \frac{2}{3} \tag{11}$$

Notice that $9/17 < \widetilde{\delta}^{\mathrm{o}} < \overline{\delta}^{\mathrm{o}} = 4/5$. The following proposition summarizes the above discussion.

Proposition 4. When collusion takes place between owners, while managers behave non-cooperatively, collusion is easier to sustain if the punishment switches from $-1/3$ (symmetric NE) to -1 (the worst punishment), but is still harder to sustain compared to the case where firms are entrepreneurial (strict profit maximizers).[9]

This result holds because reverting to the asymmetric Nash equilibrium in the event of deviation inflicts higher losses to the deviant owner which, all things being equal, increases the likelihood of collusion.

Second, when owners do not to delegate and collude on the output market, owners remain entrepreneurial if one of them defects. This subgame perfect equilibrium does not constitute the hardest punishment. In fact, the hardest punishment is to become managerial and to set $\theta_i = -1$ in the subsequent period. In this case:

$$\widehat{\delta^o} = \frac{\pi_i^D - \pi_i^C}{\pi_i^D - \pi_i^N} = \frac{1/4 - 1/8}{1/4 - 1/16} = \frac{1}{3} \tag{11}$$

The threat to hire a manager with a very strong incentive ($\theta_i = -1$) makes collusion likely to sustain, even more than under Cournot.

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[9] The analysis of collusion between owners to the "non-delegation decision" is similarly affected.

Conclusions

Lambertini and Trombetta (2002) have tackled the issue of whether delegation affects firms' ability to collude in a model of repeated Cournot competition. In this paper, the same framework is used to investigate whether the way firm owners deal with their managers influences cartel stability. Managerial bonus systems based on relative profits are compared to those based on profits and sales. The results clearly show that the type of contracts owners use to compensate their managers does matter for cartel stability. Furthermore, when owners use asymmetric punishments, collusion is very likely.

Future research might extend the analysis to other managerial bonus systems (e.g., market share) and in different competitive settings (e.g., Bertrand).[10] It might also expand the scope of the analysis to include the decision of firm owners to choose the type of contract with which to compensate their managers. In such a case, asymmetric managerial compensation contracts are expected to emerge in equilibrium.[11] Discussing side payments between managers and/or between owners might also be an interesting research topic.

Finally, this research might be of importance for antitrust agencies. The result that managerial incentive contracts affect firms' ability to collude highlights an additional tool that regulators might use in preventing collusion, they might consider not only the number and concentration of firms in an industry but also the executive compensation packages where collusion is suspected.

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[10] See Ritz (2008), who, along with Jansen et al. (2007), analyzes the market-share version of the standard two-stage delegation game (both the Cournot and Bertrand versions).

[11] This issue has already been challenged in non-repeated strategic delegation games, see Jansen et al. (2009) and Manasakis et al. (2010).

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