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DELLE ISTITUZIONI E DELLO SVILUPPO

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www.unicatt.it/dipartimenti/diseis

Università Cattolica del Sacro Cuore, Via Necchi 5, 20123 Milano

www.vitaepensiero.it

ISBN 978-88-343-1705-1

Observable and Renegotiable Contracts as Commitments to Cooperate*

Guido Merzoni**

February 20, 2008

Abstract

We study an example of strategic delegation in Cournot duopoly and show that if contracts are both observable and renegotiable before becoming common knowledge at the outset of the delegated game, the strategic value of contracts is preserved, but the set of equilibria is greatly enlarged. Managerial contracts can be used by owners to co-ordinate on any product market equilibrium allowing them to get a level of profit at least as large as the profit obtainable in the strategic delegation equilibrium without renegotiation, which is used as a threat point. The equilibrium set includes joint profit maximisation.

Keywords: Delegation, Observability, Renegotiation, Collusion.

JEL Classification: L2, D21, C72.

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* I would like to thank Carlo Beretta, Ferdinando Colombo, Morten Hviid, Norman Ireland, Piergiovanna Natale, Jonathan Thomas and David Ulph, for their useful suggestions and comments on previous versions of the paper. All the remaining errors are mine. My first attempts to study the problem analysed in the present paper dates back about a decade to my Ph.D. Thesis at the University of Warwick; my interest for the topic was revived by the reading of some recent papers with similar focus, and in particular Katz (2006) and Koçkesen (2007). This research was partially carried out within the Research Project D.1 Università Cattolica on "Il ruolo della reputazione nel coordinamento e nella governance".

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> *"People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices."*
>
> Adam Smith "*An Inquiry into the Nature and Causes of the Wealth of Nations"* Vol. 1, Book 1, Ch. 10, 1776

> *"The best of all monopoly profits is a quiet life."*
>
> John Hicks "Annual Survey of Economic Theory: The Theory of Monopoly" *Econometrica*, p. 8, 1935.

1 Introduction

In many economic settings players act through delegates (or agents) in order to save their own time, as well as to take advantage of the delegates' specific abilities or superior information. The relationship between delegates and their principals is often ruled by a contract, which may help to overcome possible inefficiencies characterising their relationship. That such contract can be manipulated to obtain strategic advantages has been recognised for long: following the seminal contribution by Schelling (1960), examples range from trade policy affecting domestic firms operating in international markets (Brander and Spencer, 1985; Gatsios and Karp, 1991), to managerial incentives in oligopolistic firms characterised by separation of ownership and control (Vickers, 1985; Fershtman and Judd, 1987; Sklivas, 1987), to public policy delegated to independent agencies, as for central banks (Rogoff, 1985) or income tax audits (Melumad and Mookherjee, 1989). Indeed, a suitably designed contract with her agent allows a principal to commit to a course of action she would not follow were she not delegating, and in such way to profitably affect the other players strategies.

With respect to the situation where the game is played without delegation, a player is always better off in an equilibrium with strategic delegation if she is the only one to have such option, while she may be worse off in the equilibrium where all players strategically delegate and the choice variables in the delegated game are strategic substitutes. For example, Fershtman and Judd (1987) and Brander and Spencer (1985) characterise inefficient delegation equilibria where delegates are engaged in Cournot competition in the product market.

In this paper, we address the issue of such possible inefficiency and study whether principals can instead use strategic delegation to coordinate in order to maximise their joint payoff. We analyse a model of oligopoly, where the owners of both firms delegate to their better informed managers the play of the product market game through an observable contract, designed to provide the right incentives in the face of moral hazard, and show that collusion can be sustained if delegation contracts are used as statements of the principals' intention to cooperate, and can be renegotiated to react to possible deviations.

Observability of the delegation contracts plays a key role in the present paper as well as in most of the literature on strategic delegation, where the strategic effect is obtained because the other players, be they principals or delegates, know the actual incentives of the delegate they are playing with.[1] Observability requires that all

[1] The more limited strategic role of unobservable delegation contracts has also been explored in the literature. Dewatripont (1988), Katz (1991) and Caillaud et al. (1995) show that, under asymmetric information between the principal and her agent, strategic pre-commitment can be

players know the contents of delegation contracts and they are sure that no secret renegotiation takes place. In principle this can be attained if principals and delegates have the capability to commit not to renegotiate, even when both parties would be better off by doing so. This is the usual interpretation of the observability assumption provided in the literature, although it seems to be quite a strong requirement in many settings, since it implies that the parties to a contract can be forced to abide by that, even against their consonant will.

In the present paper we instead assume that contracts are renegotiable, but, after possible renegotiations, they become common knowledge at the outset of the delegated game. The observability of the outcome of possible renegotiations may follow from some specific feature of the contract in use,[2] as the owners have an incentive to commit to make the delegation contracts common knowledge, because this allows to achieve cooperation. The fact that delegates acting on behalf of rival principals often belong to the same social group does also facilitate such a strong observability, because for that reason the circumstances under which they operate are made better observable among them.

Another key feature of strategic delegation models with multiple principal-agent pairs is the need that the selected contracts are mutually consistent with respect to the satisfaction of the participation constraints of the agents. When contracts are non-renegotiable or renegotiation-proof, this requirement is implicitly satisfied by the equilibrium in the one-shot contract-setting game. When contracts are renegotiable, the requirement of mutual

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attained even if the contents of contracts are not perfectly observable, when a distortion in the decision to be taken by the delegate is needed for incentive compatibility. More recently, Fershtman and Kalai (1997) for a specific example, Koçkesen and Ok (2004) in a one-sided delegation setting and Koçkesen (2007) in a two-sided delegation setting have shown the strategic value of delegation contracts with unobservable content, when the delegated game has a sequential nature.

[2] For instance with special requirement on the procedure to approve them by the governing bodies of the firm or on the need to deposit in public records.

consistency has to be satisfied only by the contracts that are current when the delegated game is played. Hence, the set of contracts that delegates are prepared to accept as a first offer by their principals greatly enlarges, because delegates know to be able to remedy possible inconsistencies of the contracts selected by calling for a renegotiaton. In our model, a delegate may accept a contract allowing him to get his reservation utility only if joint profit maximisation prevails in the product market, because he realises that any deviation by the rival firm, which would deprive him from the "quiet life" of collusion, can be matched by a renegotiation and would not therefore cause his participation constraint to be violated.

We study a variation of Fershtman and Judd (1987) and Sklivas (1987) delegation game for the case of Cournot duopoly. After contracts have been signed, before outputs are selected by the managers, a round of renegotiation can take place. Renegotiation will definitely be started by a manager who realises that his participation constraint is violated by the lack of consistency between his own and the rival firm current contract. For the same reason, if renegotiation takes place in one firm, the rival principal-agent pair renegotiate too. The option of renegotiating allow the parties to experiment on the possibility to cooperate, exploit the ability of their managers to observe their rival's contract to detect possible deviations, and so to support a joint profit-maximising equilibrium. Indeed, in this setting any deviation from an (implicit) collusive agreement would be ineffective, because it would violate contracts' consistency and so trigger a renegotiation.

Previous examples of strategic delegation models where cooperation between principal-agent pairs obtains are Fershtman, Judd and Kalai (1991) and, more recently, Katz (2006). Fershtman, Judd and Kalai (1991) derive a folk theorem for delegation games, where principals use target compensation schemes that are contingent on the principal's payoff and becomes flat at the value corresponding to joint payoff maximisation. The particular shape of the incentive schemes they consider limits the scope of their result, which would not survive the introduction of moral hazard, because in target contracts agents obtain the same compensation for a wide range of different actions they might take. In the present paper we consider a moral general incentive contracts, which makes each manager play a unique best reply to the rival firm's strategy.

Katz (2006) shows that cooperation prevails if delegation contracts can be made contingent on one another; with such a possibility the agents choices in the delegated game are not independent and each agent punishes the rival principal-agent pair if a contract that does not lead to joint payoff maximisation has been selected. The main result of the present paper has a similar flavour, because delegates' strategies in the delegated game are made somehow interdependent. However, this is obtained without an open commitment to cooperation, which would be rather unrealistic in some possible settings, as for our main application to oligopoly.

In section 2 the basic model is presented and the benchmark case equilibrium is determined; in section 3 the setting with observable and renegotiable contracts is analysed; section 4 concludes.

2 The basic model

As a benchmark we consider a slight variation of the model of delegation in duopoly by Fershtman-Judd (1987) and Sklivas (1987). The only main difference is in the utility function of the delegates, which includes a term for the disutility of effort proportional to the quantity produced.

In a symmetric homogeneous-good Cournot duopoly, firms face the following inverse demand function

$$p = a - b(q_1 + q_2) \tag{1}$$

where p is the price of the product, q_1 and q_2 are the output levels of firm *1* and *2*, and parameter b, the market scale, is a random variable uniformly distributed over the interval $[\underline{b}, \overline{b}]$. Only a subset of the individuals in the economy, the managers, observe the market scale b before the output levels are chosen and production is carried out. That is why they are delegated the choice of the output level by the owners, who retain residual claims on profits. Apart from the managers' remuneration, the firms' production costs are linear in output and, for simplicity, no fixed costs are considered. Hence firm i's revenues and profit, gross of the manager's compensation, are

$$R_i = [a - b(q_1 + q_2)]q_i \qquad i=1,2 \qquad (2)$$

$$\Pi_i = [a - b(q_1 + q_2)]q_i - c_i q_i \qquad i=1,2 \qquad (3)$$

The relationship between each owner and her manager is regulated by a contract which makes the managerial compensation contingent on the outcome of the firm's activity. In general the incentive contract may have many different shapes, but for simplicity we limit ourselves to the case where it is a linear combination of gross profits and revenues:

$$W_i = T_i[E(b)] + [w_i \Pi_i + (1 - w_i)R_i] = T_i[E(b)] + [R_i - w_i c_i q_i] \qquad i=1,2 \qquad (4)$$

where W_i is manager i's remuneration and $T_i[E(b)]$ is a fixed transfer to be determined to satisfy manager i's participation constraint. As in Fershtman-Judd (1987), the choice of the remuneration scheme is split in two parts. First, the owner chooses the parameter w_i in order to provide the manager with the desired incentives. Given the choice of w_i, the lump sum transfer $T_i[E(b)]$ is set by the owner, contingent on the expected value of the market scale *b*, in order to keep the manager at his reservation utility in expected terms. The contract is fully characterised by $T_i[E(b)]$ and w_i. Hereafter, we will denote with $W_i^k(.)$ a contract between the owner and the manager of firm *i*, i.e. a pair $\{T_i[E(b)], w_i\}$, under "regime" *k* and w_i^k the associated parameter w_i.

Owners maximise profits net of the managers' compensations

$$\pi_i = \Pi_i - W_i = [a - b(q_1 + q_2)]q_i - c_i q_i - [T_i[E(b)] + (R_i - w_i c_i q_i)] \quad (5)$$

and choose their respective managers' incentive schemes, knowing the managers' preferences and reservation utility. For simplicity we normalise the reservation utility of both managers to be equal to zero, $u_i^0 = 0$. Both managers have the following additively separable utility function

$$U_i = f_i(W_i) - e_i(q_i) \qquad i=1,2 \qquad (6)$$

where $e_i(q_i)$ is the manager's disutility of effort, $f_i^{'}(W_i) > 0$ and $e_i^{'}(\mathrm{q_i}) > 0$. The manager's disutility of effort is increasing in output, accounting for the fact that the total amount of effort increases in the size of the firm's activity. For simplicity, but without loss of generality, we assume that all the players are risk neutral and the managers' utility function is linear in output, i.e.

$$U_i = W_i - e_i q_i \qquad i=1,2 \qquad (6a)$$

When managerial contracts are simultaneously chosen and non-renegotiable, and so principals are endowed with perfect commitment capability, the setting of this model very closely resembles the one in Fershtman-Judd (1987). The structure of the duopoly delegation game is the following:

Game 1 - Strategic delegation with Perfect Commitment Capability

Stage 1. The owners simultaneously choose the incentive schemes for their managers, W_i (.), which become immediately common knowledge to all managers and owners.

Stage 2. Each manager i, after observing b, his own and his rival's incentive schemes, $W_1(.)$ and $W_2(.)$, chooses the level of output of his firm. Firms' profits and managers' remunerations are then determined by the market.

The Sub-game Perfect Equilibrium (S.P.E.) of Game 1 is determined in the following lemma. We call this the strategic contracting equilibrium, we use it as a benchmark for the analysis of the following section, and label all the equilibrium values which refer to it with superscript s.

Lemma 1. In the S.P.E. of Game 1 the incentive schemes for the managers and the levels of output produced are given by:

$$w_1^s = 1 - \frac{a - 3e_1 + 2e_2 - 3c_1 + 2c_2}{5c_1}$$

$$T_1^s = e_1 q_1^s [E(b)] - \left\{ R_1[E(b)] - w_1^s c_1 q_1^s [E(b)] \right\},$$

$$w_2^s = 1 - \frac{a - 3e_2 + 2e_1 - 3c_2 + 2c_1}{5c_2}$$

$$T_2^s = e_2 q_2^s [E(b)] - \left\{ R_2[E(b)] - w_2^s c_2 q_2^s [E(b)] \right\}$$

$$q_1^s = \frac{2(a - 3e_1 + 2e_2 - 3c_1 + 2c_2)}{5b}$$

$$q_2^s = \frac{2(a - 3e_2 + 2e_1 - 3c_2 + 2c_1)}{5b}.$$

Proof. See Appendix 1.

It is easy to see that in equilibrium the participation constraints of the delegates bind, so that they are kept at their reservation utility.

Also, if $q_1^s > 0$ and $q_2^s > 0$, then $w_1^s < 1$ and $w_2^s < 1$. This amounts to a move away from profits maximisation in the managers' objective functions, which involves a lower weight on unit costs and so an upward shift of the managers' reaction functions in the output-setting game. Managers behave more aggressively than profit maximisation would require. So, the equilibrium choice of output would not be individually rational if the output-setting game was played directly by the owner, who would renegotiate the contract if he could do it secretly, to go back to a game played with her own preferences. In fact, in a game with undetectable renegotiations the owner of one firm could induce her manager to respond optimally to the rival strategic contracting equilibrium choice. However, a secret renegotiation cannot be an available option, otherwise the owner loses her perfect commitment capability and the rival would take advantage of knowing that the owner’s delegate has the same preferences as his principal. The strategic contracting equilibrium results, yielding greater output levels, and so lower profits, than in the usual Cournot setting.

3 Observable and Renegotiable Contracts

In this section we assume that contracts are renegotiable, but they are still common knowledge when the play of the delegated game starts. Hence we assume that observability does not follow from perfect commitment capability, but depends on the outcome of possible renegotiations being observable. In this setting we show that the set of equilibrium contracts includes not only the strategic contracting equilibrium analysed in the previous section, but also all the allocations allowing each firm to get at least the profit of the strategic contracting equilibrium, which is used as a threat point in the contract-setting game.

The assumption that contracts are common knowledge even though they are renegotiable at earlier stages would be satisfied by big companies chief executives' contracts, which usually have to be ratified by the shareholders' assembly. Furthermore, the fact that all chief executives come from the same social group should facilitate and perhaps give them a reason for monitoring each other. Anyway, it turns out that building a mechanism which makes delegation contracts common knowledge at the start of the delegated game is desirable for the owners, since it allows them to co-ordinate on a collusive outcome.

We allow only one round of renegotiation to take place. At an intermediate stage, in between the signing of the managerial contracts and production, either one owner-manager pair or both can agree to renegotiate or, alternatively, one of the managers or both can force a renegotiation on their counterpart by threatening to give up the job. In any of these cases, both managerial contracts are simultaneously renegotiated. Otherwise, contracts remain unchanged.

It might be clarifying to notice, already at this stage, that once renegotiation takes place in one firm the contract selected in the rival firm may no longer be an equilibrium, since the participation constraint of the manager may get violated. This is typically the case when an owner tries to make an output-increasing renegotiation. Hence, such an outcome of a unilateral renegotiation by one firm cannot be common knowledge at the outset of the delegated game without causing a renegotiation in the other firm called by the manager, whose participation constraint would be violated otherwise. As a consequence, the proposed structure for the renegotiation process has to be thought as a reduced form for a sequence of renegotiations and counter-renegotiations by the two firms, which may take place before the output-setting game is started.

The structure of the game with renegotiation is slightly modified from Game 1 to include a further stage as follows.

Game 2 - Delegation with One Round of Renegotiation

Stage 1. The owners simultaneously choose the incentive schemes for their managers.

Stage 2. $W_1(.)$ and $W_2(.)$, selected at stage 1, become common knowledge. If either manager or both call for a renegotiation, the incentive schemes are simultaneously renegotiated in both firms. If either owner or both call for a renegotiation and at least one manager accepts to do so, the incentive schemes are simultaneously renegotiated. Otherwise, the contracts remain unchanged.

Stage 3. The current contracts, after possible renegotiations, become common knowledge. Each manager i, after observing *b*, given the possibly renegotiated incentive schemes, chooses the level of output of his firm, which becomes observable to his owner. Firms' profits and managers' remuneration are determined by the market.

We confine our attention only to symmetric equilibria.

It is easy to see that if renegotiation takes place, the choice of a new contract to replace the old one is equivalent to the choice of the contract in stage 1 of Game 1. Therefore, whenever renegotiation takes place, the equilibrium of Game 2 is the strategic contracting equilibrium we have calculated for Game 1. The set of equilibria of Game 2 may however include also further renegotiation-proof equilibria. In order to determine the set of renegotiation-proof equilibria, it is useful to introduce the following definition of mutual consistency of the incentive schemes.

Definition 1 - Mutually Consistent Contracts. A pair of contracts $\{W_1(.), W_2(.)\}$ are mutually consistent, if, once implemented, they allow both managers to get at least their reservation utility, i.e., $U_1\left[W_1\ (.), W_2\ (.)\right] \geq u_1^0 = 0$ and $U_2\left[W_1\ (.), W_2\ (.)\right] \geq u_2^0 = 0$.[3]

If a pair of non-mutually consistent incentive schemes are chosen, one of the managers or both would call for a renegotiation. If the incentive schemes are mutually consistent, then both managers receive at least their reservation utility and so have no incentive to call for a renegotiation. Mutual consistency is therefore a necessary condition for no renegotiation in equilibrium.

Lemma 2. A pair of contracts are renegotiation-proof only if they are mutually consistent.

Within the set of mutually consistent contracts we distinguish a sub-set of optimal mutually consistent contracts which give to the managers exactly their reservation utility.

Definition 2 - Optimal Mutually Consistent Contracts. A pair of contracts are optimal mutually consistent, if they are mutually consistent and allow the managers to get just their reservation utility, i.e. $U_1\left[W_1\ (.), W_2\ (.)\right] = u_1^0 = 0$ and $U_2\left[W_1\ (.), W_2\ (.)\right] = u_2^0 = 0$.

The set of optimal mutually consistent contracts contains both contracts which are better and contracts which are worse for the owners than the equilibrium contracts of Game 1. Let W^{s+} be the set of optimal mutually consistent contracts leading both firms to level of output higher than q_i^s, the strategic contracting equilibrium output. As quantities are strategic substitutes, any pair of contracts

[3] The mutual consistency requirement is obviously satisfied by the equilibrium of Game 1, since the simultaneous maximisation of the owners' objective functions satisfy the participation constraints of their managers.

$W \in W^{s+}$ is worse for the owners than the strategic contracting equilibrium, because it implies lower gross profits and higher remuneration to pay for the increased effort of the managers. Therefore, in equilibrium the owners will call for a renegotiation if $W \in W^{s+}$.

On the other hand, let W^{s-} be the set of optimal mutually consistent contracts leading both firms to produce less than in the strategic contracting case and more or equal to half the joint profit maximising output. Any $W \in W^{s-}$ is better for the owners than the strategic contracting equilibrium, since both firms' gross profits increase as their outputs are reduced until the joint profit maximising level is reached, whereas lower level of output imply lower wages to be paid to managers. Therefore, we can state the following lemma.

Lemma 3. If delegation contracts are common knowledge at the outset of the delegated game, the subset W^{s-} of optimal mutually consistent contracts is renegotiation-proof.

Proof. Any pair of contracts belonging to W^{s-} is preferred by the owners to the strategic contracting equilibrium which results from a renegotiation and provide the managers with their reservation utilities. Therefore, managers and owners will not call for a renegotiation in equilibrium. (Q.E.D.)

Now we are ready to prove the following proposition.

Proposition 4. In a duopoly game with delegation and one round of renegotiation whose outcome is perfectly observable, a symmetric pair of linear contracts W^r is an equilibrium if and only if $W^r \in W^{s-}$.

Proof. For any pair of incentive schemes $\{W_1^r(.), W_2^r(.)\} \in W^{s-}$ it is true that $E\{\pi_i\,[W_1^r(.), W_2^r(.)]\} \geq E\{\pi_i\,[W_1^s(.), W_2^s(.)]\}$ for *i=1,2*. Let

q_1^r and q_2^r be the Nash equilibrium levels of output of the Cournot game where managers have incentive schemes $\{W_1^r(.), W_2^r(.)\}$. Proposition 4 says that the following is a sub-game perfect equilibrium of Game 2:

$\{W_1^r(.), W_2^r(.)\}$;

no renegotiation;

q_1^r, q_2^r.

As above, the game is solved starting from the last stage and moving backward.

At stage 3, if the selected incentive schemes are $W_1^r(.)$ and $W_2^r(.)$, the managers, by definition, choose q_1^r and q_2^r. They are the Nash equilibrium of the Cournot game where managers have incentive schemes $W_1^r(.)$ and $W_2^r(.)$. For any other pair of mutually consistent remuneration schemes, including $W_1^s(.)$ and $W_2^s(.)$, the equilibrium output levels will be the Cournot-Nash equilibrium of the output setting game resulting from the managers having those remuneration schemes. Any pair of incentive schemes not mutually consistent will be renegotiated at stage 2. Hence, no manager will confront the choice of output with a remuneration scheme not allowing him to get at least his reservation utility in expected terms.

At stage 2 neither manager calls for a renegotiation if the pair of incentive schemes chosen by the owners are mutually consistent, but they choose to renegotiate otherwise. If either manager chooses to renegotiate, the incentive schemes are simultaneously renegotiated, the game becomes equal to Game 1 and $W_1^s(.)$ and $W_2^s(.)$ are selected.

Owner i calls for a renegotiation if the expected profit net of her manager's remuneration for the pair of contracts selected at stage 1 is smaller than the net expected profit in the strategic contracting equilibrium, i.e. if $E\left\{\pi_i\left[W_1(.), W_2(.)\right]\right\} < E\left\{\pi_i\left[W_1^s(.), W_2^s(.)\right]\right\}$. Hence, if the pair of contracts selected at stage 1 is $\left\{W_1(.), W_2(.)\right\} \in W^{s+}$, the owners will call for a renegotiation. Given that the pair of contracts selected at stage 1 are optimal mutually consistent, the managers agree to renegotiate, because they are already at their reservation utility and so are indifferent between renegotiating and confirming the contracts. If the pair of contracts selected at stage 1 are mutually consistent, but not optimal mutually consistent while both $U_1\left[W_1(.), W_2(.)\right] > u_1^0$ and $U_2\left[W_1(.), W_2(.)\right] > u_2^0$ hold, the managers will not renegotiate. Otherwise, at least one manager agrees to start a renegotiation.

At stage 1 the owners select a pair of optimal mutually consistent contracts $\left\{W_1^r(.), W_2^r(.)\right\} \in W^{s-}$. A pair of non-mutually consistent contracts will not be selected, because otherwise at least one manager will call for a renegotiation at stage 2 and the equilibrium contracts will be $\left\{W_1^s(.), W_2^s(.)\right\}$, which are strictly worse than $\left\{W_1^r(.), W_2^r(.)\right\}$ for the owners.

Non-optimal mutually consistent contracts will not be selected, because the owners can always choose a pair of contracts allowing them to give their managers the same incentives at a lower cost by adjusting T_i. Furthermore, an owner will not select a contract which gives more than his reservation utility to the manager, because the manager would refuse to renegotiate that contract if the owner wanted to do so.

An optimal mutually consistent pair of contracts $\left\{W_1(.), W_2(.)\right\} \in W^{s+}$ will not be selected because they will be renegotiated at stage 2 to get $\left\{W_1^s(.), W_2^s(.)\right\}$, which are preferred by the owners while keeping the managers at their reservation utility.

Finally, any $\{W_1^r(.), W_2^r(.)\} \in W^{s-}$ is an equilibrium, because no owner can profitably deviate from it by selecting any other contract at stage 1, since any profitable deviation instigates a renegotiation. To be profitable, a deviation must involve an increase in the level of output, since $q_i^r < q_i^s$ implies $w_i^r > w_i^s$, while w_i^s is the Nash equilibrium of the contract-setting game without renegotiation and the w_i are strategic substitutes. A deviation implying an increase in the output of the deviating firm reduces the price of the product and so the rival firm's profit. A reduction in the rival firm's profit violates the participation constraint of the manager, who would then force a renegotiation. (Q.E.D.)

The mutual consistency requirement implies that each owner chooses the incentive scheme taking both her own and her rival manager's participation constraints into account. If either owner deviates from a given pair of optimal mutually consistent incentive schemes trying to increase her profits, her rival's manager participation constraint gets violated, and so the contract in use in the rival firm is no longer an equilibrium. Renegotiation takes place and the game transforms into the previously discussed Game 1, whose equilibrium is the strategic contracting equilibrium $\{W_1^s(.), W_2^s(.)\}$. Therefore, mutually consistent pairs of incentive schemes - preferred by both owners to the strategic allocation but not attainable as a Nash equilibria of the game without renegotiation - can be implemented, because the threat of deviation is made void by the possibility of renegotiation. The strategic contracting equilibrium is used as a threat point to sustain better allocations.

As we have just seen, the delegation game with renegotiation has a continuum of equilibria $\{W_1^r(.), W_2^r(.)\} \in W^{s-}$. So we face an equilibrium selection problem. If the incentive schemes selected by the owners are not mutually consistent, one of the managers will expect not to get his reservation utility and ask for renegotiation, going back to the strategic contracting equilibrium, the only stable equilibrium of the game. Nonetheless, the equilibrium selection problem may be tackled by using a focal point argument. As it is well known, a linear Cournot duopoly game has a unique Pareto efficient symmetric allocation: the one corresponding to the joint profit maximising outputs. Choosing that allocation, within a continuum of equilibria, seems quite an obvious way to play Game 2. Therefore we can state the following proposition.

Proposition 5. Let $\{W_1^c(.), W_2^c(.)\}$ be the pair of optimal mutually consistent linear incentive schemes implementing the output levels corresponding to joint profit maximisation net of the managers' remuneration. The focal point sub-game perfect equilibrium of a duopoly model with delegation and perfectly observable renegotiation is the following

$\{W_1^c(.), W_2^c(.)\}$*;*

no renegotiation;

q_1^c, q_2^c.

The contract and the output levels corresponding to joint profit maximisation can be easily calculated as shown in Appendix 2: they are:

$$w_1^c = w_2^c = w^c = \frac{a - e + 3c}{4c} = 1 + \frac{a - e - c}{4c}, \qquad (7)$$

$$T_1^c = T_2^c = T^c = eq^c[E(b)] - \{R \;\; [E(b)] - w^c c \;\; q^c[E(b)]\} \qquad (8)$$

$$q_1^c = q_2^c = q^c = \frac{(a - e - c)}{4b}. \qquad (9)$$

We notice that if in equilibrium $q^c > 0$, then $w^c > 1$. This implies that in any equilibrium when firms find it worth producing, the weight on unit costs in the managers' objective is more than for profit maximisation, so that managers' reaction functions are shifted downward. Managers are more cautious than profit maximisation would require.

A final remark on the choice of linear managerial contracts among all the possible kind of contracts available is due. Linear contracts allow the attainment of the best symmetric allocation in the output-setting game, i.e., joint profit maximisation. Therefore, they are an optimal choice in the contract setting game.

4 Conclusion

By studying a simple model of a duopoly game played by managers on behalf of their principals, we have shown that delegation contracts, which are observable at the outset of the delegated game even though they are renegotiable earlier on, can be used to implement cooperation.

Observability requires that contracts are common knowledge when the delegates start to play; but contracts that are not mutually consistent cannot be common knowledge, because a delegate who realises to be unable to get his reservation utility would simply walk away to trigger a renegotiation. Hence, if we are really prepared to admit that delegation contracts are observable, we should conclude that a principal cannot implement a deviation from a cooperative agreement by instructing her agent to do so through one such a contract. This is the main source of our result.

Finally, and somehow less important, for the specific case of duopoly that we extensively use as our main example, it is interesting to note that the delegation contract used to implement collusion in this paper implies that managers' remuneration is positively related to profits and so it cannot be easily detected as an anti-competitive practice. Hence, delegation should probably be added to the list of practices that deserve the scrutiny of anti-trust authorities.

Appendix 1

Proof of Lemma 1

Game 1 is solved by applying backward induction. At stage two, both managers maximise the difference between their remuneration and disutility of effort:

$$\underset{q_i}{Max} \quad U_i = T_i + R_i - w_i c_i q_i - e_i q_i \qquad i = 1,2 \qquad i \neq j \tag{A1}$$

Therefore, the optimum choice of q_i will be a function of both the parameters w_i in the incentive schemes:

$$q_i = \frac{\left(a - 2e_i + e_j - 2c_i w_i + c_j w_j\right)}{3b} \tag{A2}$$

At stage one both owners take the consequences of their choices of w on their managers decisions into account and maximise their expected net profits:

$$\underset{w_i}{Max}\ E(\pi_i) = \int_{\underline{b}}^{\bar{b}} \left\{ \left[a - \left(\frac{\left(a-2e_i+e_j-2c_i w_i+c_j w_j\right)}{3} + \frac{\left(a-2e_j+e_i-2c_j w_j+c_i w_i\right)}{3} \right) \right] \left(\frac{\left(a-2e_i+e_j-2c_i w_i+c_j w_j\right)}{3b} \right) - \left(e_i + c_i\right) \frac{\left(a-2e_i+e_j-2c_i w_i+c_j w_j\right)}{3b} \right\} f(b)\,db$$

$$i = 1,2 \qquad i \neq j \tag{A3}$$

where $f(b)$ is the density function for b and in the objective function we have already substituted the participation constraint

$$-\int_{\underline{b}}^{\bar{b}} e_i \frac{\left(a-2e_i+e_j-2c_iw_i+c_jw_j\right)}{3b} f(b)db - E\left[T_i(b)+\left(R_i-w_ic_iq_i\right)\right] \geq 0$$

(A3a)

which binds in equilibrium.[4]

We notice that, given managers' and owners' risk neutrality the maximand for the owners' problem can be written as a function of the expected value of $\frac{1}{b}$, that we denote by $\frac{1}{\hat{b}}$. Hence, *(A3)* becomes

$$\underset{w_i}{Max}\; E(\pi_i) = \left[a - \left(\frac{\left(a-2e_i+e_j-2c_iw_i+c_jw_j\right)}{3} + \frac{\left(a-2e_j+e_i-2c_jw_j+c_iw_i\right)}{3}\right)\right] \left(\frac{\left(a-2e_i+e_j-2c_iw_i+c_jw_j\right)}{\hat{b}}\right) - \left(e_i+c_i\right)\frac{\left(a-2e_i+e_j-2c_iw_i+c_jw_j\right)}{\hat{b}}$$

i = 1,2 i ≠ j *(A3b)*

From the simultaneous solution of the two maximisation problems in (A3b), for firm 1 and 2, we obtain

$$w_1^s = 1 - \frac{a-3e_1+2e_2-3c_1+2c_2}{5c_1} \qquad (A4a)$$

[4] The relationships between managers and owners are characterised by an informational asymmetry. However, as we have seen, this does not give rise to opportunistic behaviour of the managers, since output and the market size are revealed to the owners ex-post. Therefore, there is no need for an incentive compatibility constraint in the owner maximisation problem; only the participation constraint holds and the manager is kept at his reservation utility.

$$w_2^s = 1 - \frac{a - 3e_2 + 2e_1 - 3c_2 + 2c_1}{5c_2}. \qquad (A4b)$$

Finally, by substituting w_1^s and w_2^s in equation *(A2)*, we get

$$q_1^s = \frac{2(a - 3e_1 + 2e_2 - 3c_1 + 2c_2)}{5b} \qquad (A5a)$$

$$q_2^s = \frac{2(a - 3e_2 + 2e_1 - 3c_2 + 2c_1)}{5b}. \qquad (A5b)$$

(Q.E.D.).

Appendix 2

The equilibrium contracts and output in the collusive equilibrium are easily calculated as follows. At stage 3 the managers choose the optimum levels of output exactly as in the strategic case. Hence, the choice of manager i will be as in equation *(A2)*:

$$q_i = \frac{(a - 2e_i + e_j - 2c_i w_i + c_j w_j)}{3b} \quad \text{i, j} = 1,2 \quad \text{i} \neq \text{j} \qquad (A2)$$

In the perfectly symmetric case, *(A2)* reduces to:

$$q_i = \frac{(a - e - cw)}{3b} \qquad (A6)$$

Given these decision rules, the owners choose the incentive schemes in order to make the sum of q_1 and q_2 equal to the joint profits maximising output Q^c:

$$q_1^c = q_2^c = \frac{Q^c}{2} \tag{A7}$$

The joint profit maximising output is simply determined by solving the following:

$$\underset{Q}{Max} \quad (a - bQ)Q - (e + c)Q \tag{A8}$$

Hence,

$$Q^c = \frac{(a - e - c)}{2b} \tag{A9}$$

while

$$q_1^c = q_2^c = q^c = \frac{(a - e - c)}{4b} \tag{A10}$$

Substituting *(A10)* in *(A6)* we get:

$$\frac{(a - e - cw)}{3b} = \frac{(a - e - c)}{4b} \tag{A11}$$

which allows us to calculate the parameter w of the collusive incentive scheme:

$$w_1^c = w_2^c = w^c = \frac{a - e + 3c}{4c} = 1 + \frac{a - e - c}{4c}. \tag{A12}$$

References

Brander J.A. and B.J. Spencer (1985) “Export subsidies and international market share rivalry”, *Journal of International Economics*, 18, pp.83-100.

Caillaud, B., Jullien, B. and P. Picard (1995) “Competing Vertical Structures: Pre-commitment and Renegotiation”, *Econometrica*, vol. 63, pp. 621-646.

Dewatripont, M. (1988) "Commitment Through Renegotiation-Proof Contracts with Third Parties". *Review of Economic Studies*, vol.55, pp.377-390.

Fershtman, C. and K. Judd (1987) "Equilibrium Incentives in Oligopoly", *American Economic Review*, vol.77, pp.927-940.

Fershtman, C., Judd, K. and Kalai, E. (1991) "Observable Contracts: Strategic Delegation and Co-operation", *International Economic Review*, vol.32, no.3, pp.551-559.

Gatsios, K. and L. Karp (1991) “Delegation games in Customs Unions”, *Review of Economic Studies*, vol.58, pp.391-397.

Katz, M. (1991) "Game-playing agents: unobservable contracts as pre-commitments", *Rand Journal of Economics*, vol.22, no.3, pp.307-328.

Katz, M. (2006) "Observable Contracts as Commitments: Interdependent Contracts and Moral hazard", *Journal of Economics & Management Strategy*, vol.15, no.3, pp.685-706.

Koçkesen, L. and Ok, E. (2004) "Strategic Delegation By Unobservable Incentive Contracts", *Review of Economic Studies*, vol.71, pp.397-424.

Koçkesen, L. (2007) "Unobservable contracts as precommitments", *Economic Theory*, vol.31, pp.539-552.

Melumad, N.D. and Mookherjee, D. (1989), Delegation as commitment: the case of income tax audits, *Rand Journal of Economics*, vol.20, n.2, pp.139-163.

Rogoff, K. (1985) "The Optimal Degree of Commitment to an Intermediate Monetary Target", *Quarterly Journal of Economics*, vol.100, no.4, 1169-1190.

Schelling, T.C. (1960), *"The Strategy of Conflict"*, Cambridge, Mass., Harvard University Press.

Sklivas, S.D. (1987) "The Strategic Choice of Management Incentives". *Rand Journal of Economics*, vol.18, pp.452-458.

Vickers, J. (1985) "Delegation and the theory of the firm". *Economic Journal*, Supplement, vol.53, pp.138-147.

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(*) Testo disponibile presso il DISEIS

Finito di stampare
nel mese di febbraio 2008
da Gi&Gi srl - Triuggio (MI)

ISBN 978-88-343-1705-1