JOINT VENTURE FOR A NEW PRODUCT: A MATTER OF TRUST

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Abstract
The paper establishes the effects of free-riding behavior by partners in a JV for a new product, when input to the JV are not verifiable. It then studies the ways in which the firms may control the incentives to free-ride and the effects that those agreements produce on the quality of the product, on profits, and on the welfare in the industry. Some Antitrust implications that justify existing tolerance by European Authorities towards JV's cooperation in sales and not only in research are finally derived.

1 Introduction

The present paper[1] is a study of how parent companies encounter and may solve some problems in the design of Research Joint Ventures. The paper refers to JV's aimed at research for product innovation rather than for cost reduction; in this respect it differs from most of the existing literature.

Parent companies must specify, among other things, what type of know-how and what resources currently owned shall be transferred to the RJV. Agreements stating the obligations of parties are difficult to write and even more difficult to enforce. As Shapiro and Willig (1990, p.114) have concisely put it,

> Decision making can be cumbersome or dysfunctional when the parents to the venture have differing objectives or opinions on the course of the market, and the danger that one parent will try to free ride on the other(s) always lurks in the background. For example, one parent company may contribute its less able personnel or withhold its most advanced technology from the venture.

There are objective difficulties to prevent free-riding or opportunistic behavior. The resources given to a RJV, by the parties involved, are not easily measurable or observable. For instance, can the value of human capital in the form of research personnel be established on any objective scale? What is the quality of the technical information, or of information on markets and customers, that a party to the JV decides to share?

The literature has so far addressed the issue of *free-riding* behavior in JV's in a rather informal way. One noticeable exception is the paper by Kamien et al. (1992) who, in the vein of most of the literature deriving from d'Aspremont and Jacquemin (1988) (see also Suzumura (1992), and De Bondt and Wu (1994)), analyze the JV's constructed with the purpose of reducing production costs. Kamien *et al.* point out that a firm may decide to free-ride on the technical input by its partners because there exist spillovers of technology improvements by other firms on one's own cost function.

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The kind of free-ride that we take into account is of a different type and it occurs whithout the presence of spillovers.The intuitive idea of free-riding motivating the paper is the following.

Suppose two firms engage in a common research project to develop a new product (or a new version of an old product); suppose also that the product's quality depends upon the input provided by the firms and that this input is costly (for instance, firms must transfer some personnel to the new project). Since the results from research efforts are pooled and end up in a single product, the provision of the input has the character of a public good; accordingly if one firm provides high levels of input the other may be content to save on costs, and provide lower levels of input. The firm that free-rides knows that the quality of the final product will be lower than it would be if both firms had provided the highest level of input, but the gains from the investment in input are shared with the partner—they are not fully appropriable—whereby the underinvestment problem.

Of course the unverifiability of input (or of investments) plays a central role in our story. In fact if input were fully verifiable by a third party, and hence contractible, then the parent companies could specify in a complete contract the behavior required by both, and the penalties for deviation from the agreement. But full verifiability is not a good approximation to reality; for instance Berg *et al.* (1982) document the importance of mutual distrust and fear of expropriation among JV's partners.

The model below gives analytical content to this informal argument and provides a tool to analyze the main questions: what can the firms do to control the incentive to free-ride? What effects on the quality level have the different types of agreements among partners? Do these violate Antitrust norms? Is there a social interest to reduce the free-ride and therefore to tolerate interfirm agreements that violate Antitrust norms?

Section 2 describes the assumptions and the model. Section 3 studies the effects on the quality of the product of different contractual arrangements. It is there shown that the "producers first-best" quality, i.e. the quality in the hypothetical case when the input are fully verifiable, cannot be achieved under non-verifiability if firms compete at the marketing stage. Other forms of cooperation are then studied. In particular it is shown that a restrictive agreement on the quantities supplied improves quality, with respect to the case of Cournot-type quantity competition, although in all generality the producers first best cannot be obtained.

The question then is whether this cartel-like output agreements should or should not be allowed by the Antitrust authorities, in view of the public interest. The answer we provide is positive for JV's of the kind here analyzed. It is shown below that both consumer and producer surpluses may be higher under collusive behavior on the output market.

This result provides a rationale for the alleged tolerant attitutde towards joint marketing (at least for the case of JV's for a new product) by EEC authorities. It should be reminded that in Europe there exist special regulation for RJV's (especially articles 85 and 86 and Regulation 151/93). In The US, the National Cooperative Research Act of 1984 offers limited protection against Antitrust action to RJV's as discussed by Katz and Ordover (1990). Although we are not able to assess here the degree of tolerance of US authorities, we feel justified enough to assert that the EEC Antitrust has rarely (in fact to our knowledge *never*) refused consent to agreements on joint marketing.

Other works on the subject include Grossman and Shapiro (1986) and Ordover and Willig(1985), where the Antitrust issues are debated at length, Bergs *et al.* (1982) and Harrigan (1985) who provide empirical material and case studies, that also motivate our work. Batthacharya *et al.* (1992) deal with unobservability of the input by parents to Research agreements, their work, however is more concerned with the effects of license agreements as opposed to other forms of information sharing than with JV's.

2 The Set-up

Consider an industry with inverse demand given by

$$P = p(\theta, Q) \tag{1}$$

where P is the price and θ is a parameter that measures the technology improvements or investments in quality made by the firm producing the good. Presumably, consumers are ready to pay a higher price for higher quality levels. Hence we assume in general that

$$\frac{\partial P}{\partial \theta} > 0 \text{ and} \frac{\partial^2 P}{\partial \theta^2} \leq 0$$

For instance one could consider the class of linear functions of the type

$$P(a(\theta), b(\theta), Q) = a(\theta) - b(\theta)Q,$$

where the intercept and slope of the inverse demand both depend upon the quality of the product. This leads, however to unnecessary complications and—although we have also checked the feasibility of the analysis for the case where the intercept depends upon the quality but the slope does not—we have simplified to the specification $P(b(\theta), Q) = a - b(\theta)Q$, with most of the results derived for the case with

$$p(\theta, Q) = a - \theta^{-\beta}Q \quad \text{where} \quad 0 < \beta < 1 \tag{2}$$

where an increase in θ leads to a higher demand.

When firms pool their research efforts it is legitimate as a first approximation to assume that they will manufacture the same product, even if in reality other factors will in general intervene to differentiate the products slightly. This greatly simplifies the analysis of demand with respect to the differentiation case, and it allows isolate the free-riding strategies from the product-differentiation strategies.

We assume that the two parent companies contribute to the Research Joint Venture (RJV) by supplying the technical input in their possession. For instance one may think that a RJV requires the transfer of research personnel, of administrative staff and time, and of accumulated company knowledge. The formal representation here adopted is surely not appropriate to reflect the richness of these qualitative dimensions, but it enables the focus to be restricted to the strategic aspects of the problem.

We specify that the cost borne by parent company i is a function of only one variable, θ_i, homogeneous to that supplied by parent j, namely θ_j.

The opportunity cost to each firm of supplying an amount θ_n for $n = i, j$ is assumed to be a convex function (to maintain strict concavity of profits). Although some general results could be derived considering a more general class of cost functions, we here restrict the analysis to the function

$$F(\theta_n) \equiv \frac{1}{1+\alpha}(\theta_n)^{1+\alpha}, \tag{3}$$

with $\alpha \geq 0$. Note that the sum of the opportunity costs for the supply of the amount $\theta_i + \theta_j$ is $F(\theta_i) + F(\theta_j)$ and not $F(\theta_i + \theta_j)$. Therefore, given the form of the function $F(.)$, there is no exogenous advantage in conducting research activities separately by a single firm; this formulation allows us to attribute the dysfunction in the JV as coming only from the opportunistic behavior of the parent companies. Finally, to simplify, we assume all other production costs to be null.

We shall always denote the individual contributions by $\theta_i$and θ_j respectively and we assume that:
(i) they are unverifiable by a third party so that they are not contractible;
(ii) the resulting contribution is the sum of the two ($\theta = \theta_i + \theta_j$).

Note that the verifiability of the final result is not sufficient to set up a contract that penalizes the firm that undersupplies input with respect to pre-specified quantities: a Court could not enforce such a contract against the disclaim of the firm accused of misbehaving, because of the assumption of unverifiability of input. An alternative could be that of stipulating a contract that severely punishes all partners if the achieved quality falls short of a pre-specified threshold, but, at a closer look, this contract is also untenable, as it is clear that all partners would like to renegotiate it after the occurrence that triggers the punishment, in the language of contract theory, it would not be 'renegotiation-proof'.

We consider in succession four possible contractual forms that may link the two parent companies in a RJV. Among these, the 'producers first best' is only a hypothetical form that serves as a reference point, since it is the contract that could be obtained as a first best solution to the problem of profit maximization in the case of perfect information. It is not to be confused with the first best from a social point of view. The three remaining ones all assume unverifiable contribution levels and induce different incentives to free-ride by partners.

3 Joint Venture

3.1 Producers First Best

This subsection calculates the details of the producers first best contract. Suppose the two parent companies (i and j) supply technical input to the Joint Venture in order to create the new product. Suppose that the input quantities θ_i and $\theta_j$were verifiable. In this case a contract can be signed that specifies these quantities. Suppose further that no restriction is imposed upon joint marketing so that the product can be sold under fully collusive (monopolistic) conditions. The objective of the two parents will be that of maximizing the joint profit. This writes as the program

$$\max_{Q,\theta} \pi^*(\theta, Q) \equiv QP(Q,\theta) - 2F\left(\frac{\theta}{2}\right). \tag{4}$$

Which leads to the first order conditions

$$\frac{\partial \pi^*}{\partial Q} = Q\frac{\partial P(Q,\theta)}{\partial Q} + P(Q,\theta) = 0, \tag{5}$$

and

$$\frac{\partial \pi^*}{\partial \theta} = Q\frac{\partial P(Q,\theta)}{\partial \theta} - F'\left(\frac{\theta}{2}\right) = 0. \tag{6}$$

For further reference note that, defining $\theta_i = \frac{\theta}{2}$, the maximization program for the first best can be rewritten as:

$$\max_{Q,\theta_i} \pi^*(2\theta_i, Q) \equiv QP(Q, 2\theta_i) - 2F(\theta_i). \tag{7}$$

Within the framework of the specification here adopted for $P(Q,\theta)$ and $F(\theta)$ it is easy to calculate the optimal values for Q^* and θ^* that solves

$$\max_{q,\theta}[a - \theta^{-\beta}Q]Q - \frac{2}{1+\alpha}\left(\frac{\theta}{2}\right)^{1+\alpha}$$

they are

$$q^* = \frac{a}{2}\theta^{\beta} \text{ and } \theta^* = \left(\frac{\beta a^2 2^{\alpha}}{4}\right)^{\frac{1}{1+\alpha-\beta}}. \tag{8}$$

These values for the optimal quantity and technical input provide a reference point.

Incidentally note that the producers first best solution can be compared to the solution for a monopoly, to illustrate that given the convexity of the cost function $F(\theta)$, and under fully verifiable input, the JV is preferable to the undertaking of a research program by a single firm.

The objective function of a monopolist is $[a - \theta^{-\beta}Q]Q - [\theta^{(1+\alpha)}]/(1+\alpha)$.

This in turn can be shown to lead to the optimal values for θ given by $\theta^m = \left((\beta a^2)/4\right)^{\frac{1}{1+\alpha-\beta}}$, which is always smaller than θ^* (except when $\alpha = 0$, in which case they are equal).

3.2 Independent marketing

After analyzing the producers first best let us study the case where the research results are pooled to determine the quality of the product and no further agreement is signed on the output sold. Equilibrium on the output market is determined by Cournot type competition.

One has a two-stage game structure where at the first stage firms choose the contributions to the RJV (the θ's), and at the second they choose the output levels q_i and q_j.

A profit maximizing firm, say firm i, would choose quantity so as to maximize

$$q_i P(Q, (\theta_i + \theta_j)) - F(\theta_i), \tag{9}$$

for any given effort levels provided in the research stage.

With our specification this rewrites as

$$\max_{q_i} [a - (\theta_i + \theta_j)^{-\beta}(q_i + q_j)]q_i, \tag{10}$$

This leads to the usual first order conditions, one for each firm, that form the system to be solved to obtain the Cournot output levels, denoted by $q^c(\theta_i, \theta_j)$. It is easy to obtain $q_i^c = (\theta_i + \theta_j)^\beta (a/3) = q_j^c$, i.e. outputs are symmetric.

At the first stage firm i solves the program

$$\max_{\theta_i} [a - (2a/3)](\theta_i + \theta_j)^\beta (a/3) - \frac{1}{1+\alpha}(\theta_i)^{1+\alpha}. \tag{11}$$

A symmetric representation holds for firm j.

This gives the system of first order conditions (one for each firm), letting $n, m \in \{i, j\}$ and $n \neq m$,

$$-\beta(\theta_n + \theta_m)^{\beta-1}(a^2/9) = \theta_n^\alpha \tag{12}$$

Imposing symmetry of the solution in theta, (12) determines the effort level θ_i^c under the anticipation of the Cournot output q^c:

$$\theta_j^c = \theta_i^c = \left(\frac{\beta a^2 2^{\beta-1}}{9}\right)^z. \tag{13}$$

where $z = 1/(1+\alpha-\beta)$.

Comparing the R&D effort under Cournot competition (non-verifiability) and the producers first best RJV one obtains that

$$\frac{\theta^*}{2} = \left(\frac{\beta a^2 2^{\beta-1}}{4}\right)^z > \left(\frac{\beta a^2 2^{(\beta-1)}}{9}\right)^z = \theta_i^c. \quad (14)$$

Result 1 *If neither the output levels nor the contributions to the RJV are contracted upon, then the product quality is lower than under the producers first best solution.*

The firms' efforts and their sum when a RJV is not fully feasible due to unverifiability is lower than the corresponding efforts provided when both, quantities of output and of technical input are fully contractible. One may object that the level of θ in the RJV producers first best solution is higher due to both the elimination of the unverifiability assumption and the elimination of competition on the output market. Next section will help isolate the first factor (unverifiability) from the second (collusion).

3.3 Quantity Scheme

The unobservability, coupled with competition on the output market induces the following. Since the average cost is everywhere decreasing (marginal costs being constant) each firm shall gain a competitive advantage by making a lower effort in R&D. Obviously each firm shares an incentive to cut its own effort below that of the rival so as to increase its profit on the output sold. Under Cournot competition a firm can appropriate only part of the returns from its own investment. This consideration leads to the question whether with joint marketing the internalization is complete and the incentive to undercut disappears even if the unobservability assumption is maintained. This question is answered in the present paragraph.

Suppose now that the two parent companies do set up a joint research venture and that the quantities they produce are fully contractible while the technical input are not.

The question is whether the producers first best quality can or cannot be attained in spite of the unverifiability. The two parents can sign a contract (Antitrust allowing it) that specifies the amount each firm shall manufacture as equal to $Q*/2$, i.e. half the previously calculated first best output. Then each firm can be left free to supply the amount of technical input it wishes to. It is then clear that the quantity of input that each firm shall provide is the quantity that maximizes

$$\max_{\theta_i} \pi_{qs} = [P(Q^*, \theta_i + \theta j)]\frac{Q^*}{2} - F(\theta_i). \tag{15}$$

It is easy to prove that the first best solution is not attainable. The proof is by contradiction and it proceeds as follows. Define the notation $\frac{\partial P}{\partial \theta} = g(\theta, Q)$. Assume that the first best is achieved under the quantity scheme: Q is fixed at Q^* (each firm producing half of it) and firm i maximizes profit by choosing $\theta_i^* = \theta^*/2$. By symmetry, it should be that $\theta_j = \theta^*/2$, as well. The first order condition for firm i would verify

$$Q^* g(2\theta_i^*, Q^*) = 2F'(\theta_i^*). \tag{16}$$

On the other hand the first order condition for the first best that is given by program (7) writes as

$$Q^* g(2\theta_i^*, Q^*) = F'(\theta_i^*). \tag{17}$$

Comparing the expressions (16) and (17) we can easily verify that they cannot simultaneously hold (unless $F' \equiv 0$). Furthermore, since $F' > 0$, and since (17) is verified by definition of θ^* and Q^*, the first derivative of the profit for the quantity scheme is negative at the point (Q^*, θ^*) . Therefore if $Q = Q^*$ the quality level that satisfies (16) lies to the left of θ_i^*. In terms of the firms' behavior this means that firm i has an incentive to lower its effort below that of the partner if anybody fixed the partner's level at $\frac{\theta^*}{2}$. This justifies the following result.

Result 2 *The non-verifiability of θ_i and θ_j technical input prevents implementation of the producers first best solution. Furthermore, in all generality, the quality level of the product shall be lower under the quantity scheme than under the producers first best.*

Calculating the details of the quantity scheme for the specific cost and demand functions here considered, the maximization program writes as

$$\max_{\theta_i}[a - (\theta_i + \theta_j)^{-\beta} Q^*]\frac{Q^*}{2} - \frac{1}{1+\alpha}(\theta_i)^{1+\alpha}. \tag{18}$$

The maximum is obtained at

$$\theta_{qs} \equiv \theta_{qs} = \left(\frac{\beta a^2 2^{\beta-1}}{8}\right)^z .$$

Therefore it is possible, recalling that θ_{qs} and θ_c must be multiplied by two, to summarize the order in which the levels of qualities rank.

Result 3 *Under the specification (2) and (3) above the highest quality level is achieved under the producers first best solution, followed by the quantity scheme, and last ranks the Cournot competition case.*

The result means that if one of the objectives for the regulating authority is the achievement of a high quality standard, then it is better to tolerate some cooperation at the marketing stage rather than trying to impose a more competitive behavior, like for instance Cournot competition.

4 Welfare Implications

The achievements of the highest possible quality level is not *per se* a sufficient indicator of the overall performance of a JV. There may be however cases in which the authorities may be satisfied of quality as an indicator; for instance when the quality is essential to create a brand image for the firms in view of meeting competition from existing or forthcoming substitutes. Another situation arises when a government is not in the position to collect sufficient information about other variables like the consumers surplus or the profits of firms. Both cases may apply to countries where the technology in industry is backward and where statistics and accounting procedures are poor.

The analysis so far performed is suggestive for these applications.

In general, however, as in the standard partial equilibrium textbook analysis, a ranking of alternatives should be based on considerations of welfare in the concerned industry.

The expressions for the consumers surpluses, CS, are of the form:

$$CS = \theta^{-\beta} \frac{Q^2}{2}. \tag{19}$$

Where in general Q and θ are functionally linked as in, e.g. the "Quantity Scheme" results. The profit functions computed derive from equations (4),

(10) and (18) above, as applying to the different contracts. In order to manage the problem of comparing the rather complicated functions obtained we have fixed the value of $\alpha = 0.5$ and let β vary between 0 and 1 (we have also checked, although we have not reported, the qualitative results letting α vary between 0 and 1 and fixing $\beta = 0.5$).

The first interesting comparison shows that the consumers surplus under the Quantity scheme is higher than the one in the Cournot scheme, for values of β larger than 0.4, meaning that consumers may in some cases benefit when the two firms cooperate at the marketing stage. Formally, let CS_{qs} and CS_c denote respectively the consumer surplus for the quantity scheme and that for the "Cournot" case, one has that if $\alpha = 0.5$ the difference $CS_{qs} - CS_c$ is an increasing function of β for $\beta \in [0, 1]$, with positive values for $\beta > 0.4$ roughly, and with a maximum obtained at $\beta = 1$. It follows that:

Result 4 *Allowing for cooperation in the form of a fixed quantity agreement can ameliorate both profits and consumer surpluses with respect to the Cournot solution.*

This is a crucial point as the result makes it clear that when the quality of the product depends on the type of agreement among firms, the consumers *and* the firms may simultaneously benefit from a cooperative agreement between firms.

It is also the case that the total surplus in the industry under the quantity scheme (denoted TS_{qs}) is higher than under Cournot competition (denoted TS_c) for values of β roughly between 0.4 and 0.9. (the difference $TS_{qs} - TS_c$ is a concave function of β, with a negative minimum value for $\beta = 0$ and a maximum near $\beta = 0.6$. As for the comparison between the producers' first best and the other two solutions so far considered, one has that the total surplus for the first best (denoted TS^*) lies below the function TS_{qs} for all values of β less than 0.9 roughly. It also lies below the total surplus under Cournot (TS_c) for all values of β roughly below 0.6[2].

These results are summarized in table 1.

From inspection of the behavior of TS^*, it follows that—for overwhelmingly large parameter regions—the non-verifiability of efforts reduces profits, but it benefits consumers so as to induce a total surplus increase.

[2] All the comparisons are derived from inspections of plots of the functions through computer graphics programs and are therefore subject to rounding errors.

$\beta \in [0.4, 0.9]$	$CS_{qs} > CS_c$	$TS_{qs} > TS_c$
$\beta \in [0, 0.9]$	$TS^* < TS_{qs}$	$CS^* < CS_{qs}$
$\beta \in [0, 0.6]$	$TS^* < TS_c$	$CS^* < CS_c$
$\beta \in [0.6, 1]$	$TS^* > TS_c$	

Table-1

5 An Incentive Compatible Scheme

We consider now the joint marketing of the product under delegation of the production decision to the management of the JV. The agreement we analyze takes the following form. The parent companies agree to delegate production to the JV unit. Furthermore they decide a remuneration scheme for the JV's manager that provides him with the incentive to maximize total profit net of the cost of research. For instance the manager is paid a percentage of total profit so computed. The costs of R&D, however, depend upon the theta's, which cannot be contracted upon. A way out is then to fix the theta's at those levels corresponding to the incentive compatible values. At these levels of θ_i and θ_j neither parent company is tempted to unilaterally deviate from the agreement.

Formally, the decision problem faced by the joint venture's manager is described by the following expression:

$$\max_Q = \gamma[a - (2\theta(Q))^{-\beta}Q]Q - \gamma\frac{2}{1+\alpha}[\theta(Q)]^{1+\alpha}, \tag{20}$$

where γ is the percentage which constitutes the compensation to the manager; $\theta(Q)$ is given by the (Nash-like) simultaneous solution of the following two programs:

$$\arg\max_{\theta_n}[a - b(\theta_n + \theta_m)Q]Q/2 - F(\theta_n); \quad n, m = i, j \text{ and } n \neq m.$$

The manager of the JV then maximizes his payoff given the optimal level of effort provided by each firm. From the computation of the first order conditions for the determination of the theta's one gets the following system of equations:

$$\frac{\beta}{2}(\theta_i + \theta_j)^{-\beta-1}Q^2 = \theta_i^{\alpha}, \tag{21}$$

and by the symmetric equation, for firm j. By symmetry $\theta_i = \theta_j \equiv \theta(Q)$. This yields,

$$\theta_i(Q) = \theta_j(Q) = \left[Q^2 w\right]^{\frac{1}{h}}.$$

Where $h = (1 + \alpha + \beta)$, and $w = \dfrac{\beta 2^{-\beta}}{4}$. The manager in turn chooses Q so as to solve the program

$$\max_{Q}(a - (2\theta(Q))^{-\beta}Q)Q - \frac{2}{(1+\alpha)}(\theta(\dot{Q}))^{1+\alpha}. \tag{22}$$

The optimal values for Q, chosen by the manager, and for θ chosen by the firms are not easily comparable to those obtained for the other types of contracts in the preceding sections. Therefore it is useful to reduce the complexity of the expressions first by fixing $a = 1$.

First, let $a = 1$ and $x = \left[2^{-\beta} w^{\frac{-\beta}{h}} - \dfrac{2}{(1+\alpha)} w^{\frac{(1+\alpha)}{h}}\right]$. Then the solution for Q writes as

$$Q^* = \left[\frac{zh}{2(1+\alpha)x}\right]^{\frac{h}{1+\alpha-\beta}}. \tag{23}$$

Given the complexity of the functional forms involved here, we have performed some illustrative calculations for the values $\alpha = \beta = 0.5$.

Example values: $\alpha = 1/2$, $\beta = 1/2$.

Substituting with these values one can verify that $\theta(Q)$ is given by $Q\frac{1}{4}2^{1/4}$. The maximization program for the manager then gives a first order condition of the form $a - \sqrt{Q}(2)^{-5/8}[3 + 2^{-1}] = 0$. So that

$$Q_{ic} = 0.1942a^2 \text{ and } \theta_{ic} = 0.0577a^2.$$

Similar calculations with the same values, i.e. 1/2 and 1/2, for α and β, give the ranking

$$\theta^* > \theta_{ic} > \theta_{qs} > \theta_c$$

showing that the incentive compatible scheme, if appropriately tuned, can approach the firms to the first best solution more than any other type of contract. The fact that the result is here obtained for a particular set of values of the parameters should not be too discouraging in drawing more general inferences. The general idea is that there can be ways to improve on simple contracts—like the fixed quantity scheme—by using more elaborate type of contracts, where the incentives to the manager of the JV are so constructed as to feed back on the parent firms' decisions. We have analyzed only one incentive compatible scheme, but other types with different management remuneration could be devised according to necessity.

The ranking of profits, according to calculations using the results for the values of θ^*, of θ_{qs}, of θ_c made above is not easily done for the general case. Some indications are easily obtained for the case where $\alpha = \beta = \frac{1}{2}$. In that case one has a ranking of profits given by

$$\pi^* > \pi_{ic} > \pi_{qs} > \pi_c.$$

For the same value of alpha one gets that the consumer surpluses[3], denoted by CS rank in the order

$$CS_{qs} > CS_c > CS_{ic} > CS^*.$$

This shows that the highest profit in the situation of producers first best is associated to the lowest consumer surplus, the second highest profit, with the incentive compatible scheme, to the second lowest surplus. The order for the Cournot and the fixed quantity scheme, by contrast, is reversed, in accordance, again, with Result-5 above.

6 Conclusion

The main focus of the analysis above is on the design of RJV for a new product, or else how the contract that the parent companies design affects

[3]In particular $\pi^* = 0.07a^3$; $\pi_{ic} = 0.0647a^3$; $\pi_{qs} = 0.057a^3$; $\pi_c = 0.051a^3$. As for the surpluses one gets: $CS_{qs} = 0.074a^3$; $CS_c = 0.062a^3$; $CS_{ic} = 0.055a^3$; $CS^* = 0.052a^3$.

their behavior and the RJV results in terms of product quality, of consumers surpluses, and producers profits. It has been shown that, if unverifiability of the parents' contribution is an issue then the two companies cannot implement the producers first best. The quality levels achieved under different contractual arrangements have been compared. It has been shown that quality is ameliorated by collusive agreements on output. Furthermore, a form of agreement where a Research and production JV is set up also serves to increase quality with respect to the Cournot competition case.

Quality *per se* may be important in some cases; for instance in economies like those of LDC or of former socialist countries that are opening to trade in specific sectors and must confront international competition. More generally an assessment of welfare requires a more elaborated analysis.

The welfare comparisons here performed show that some degree of cooperation on the output market, like market sharing agreements, may benefit both firms and consumers. More generally, the impossibility of striking agreements on the output market may seriously limit the profitability of a RJV.

The above welfare comparisons may be biased by the functional forms chosen to formulate the dependence of demand upon quality and by the cost function or, more importantly, by some of the assumptions.

One can suspect, for instance, although we have no formal argument to advance to support the claim, that if partial observability of the effort levels were introduced, the incentive compatible scheme may perform better than it does in the present set-up. Also, the welfare ranking may change if the losses from litigation costs were included in some more elaborated version of the model. In that case, one should expect that incentive compatible schemes, since they are self-enforcing, minimize the chances that litigation occurs. The main Antitrust implication that can be derived from the analysis above is that leeway in the design of the contract should be given to firms that form a RJV for the development of a new product.

Furthermore, if the government searched for a control variable to maximize the social welfare from a RJV it should try and set up a quantity obligation for the output sold by the two firms. Obviously the government may suffer from information constraints in setting up appropriate production targets, and successive refinements of targets may be needed in such cases so long as evidence of results is collected through time.

In practice, furthermore, it could be of help for the Antitrust authorities to device criteria to rank the RJV according to the intensity of the free-riding incentives that they create, so as to modify the antitrust tolerance appropriately. But more research is surely needed and evidence must be collected to device such complete rules.

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