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Commitment by Delegation
Or: What's "Strategic" about Strategic Alliances?

by

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Abstract

The paper deals with two firms forming a strategic alliance in a three–firm *Cournot* oligopoly. A standard two–stage game with R&D and output decisions is used. The firms in the alliance carry out a common R&D project by delegating the decision on the level of R&D activity to one of them while remaining competitors in the output game. The results point to the strategic element of such a delegation of power to a competitor. It is the commitment value of forming an alliance that makes it "strategic" in the sense of theoretical industrial organization.

JEL–classification: D21, D43, L13

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Contents

1 Introduction

After the wave of mergers and acquisitions throughout the 1980s, so-called strategic alliances lately became fashionable among firms. A strategic alliance can be defined as a cooperation, where the partners remain independent firms which coordinate some of their activities while being competitors in other areas (for a similar definition see *Porter/Fuller, 1986*). Recent examples are coalitions among *IBM* and *Siemens* to produce a new generation of memory chips, *Rolls-Royce* and *BMW* to produce jet engines, and *Mitsubishi* and *Daimler-Benz* the details of which are still being negotiated. Strategic alliances can be found in a variety of forms, ranging from loose technological cooperation and licensing of technology to joint ventures and cross ownership. Trends towards global markets and increased technological complexity are often seen as major reasons for this new development in inter-firm relations. They both imply large fixed or sunk costs. An alliance allows to share these costs among the participating firms. Advantages arise from scale economies and learning effects, access to new technologies and new markets, risk sharing and risk spreading, and from influencing the competition in the market. This paper focuses on the latter aspect.

One could ask why such cooperations among competing firms are called "strategic". Apart from the popularity of the adjective particularly among business people, at least two economic reasons can be mentioned:

- By forming an alliance the participating firms coordinate their strategies, i.e. their "basic longterm goals and objectives [...], and the adoption of courses of action and the allocation of resources necessary for carrying out these goals" (*Chandler, 1962, p. 13*).
- By forming an alliance the participating firms want to create and/or capture economic rents in markets with perceived interdependence. To reach this goal, a strategic alliance serves as a commitment against competitors.

In this paper strategic alliances are interpreted in the sense of the latter argument. It will be shown that from a theoretical perspective one important reason for forming such a coalition among competitors is to induce favorable reactions by rivals outside the alliance.

So far, strategic alliances have been analyzed mainly in the management literature, where papers both on problems of managing an alliance and on specific forms like joint ventures can be found (cf. *Hamel et al., 1989, Harrigan, 1988a, 1988b, Kogut, 1988, Ohmae, 1989, Porter/Fuller, 1986*). Work on incentives for cooperation was done by *Contractor/Lorange (1988)* and *Buckley/Casson (1988)*. In the economics literature, older work on cartels is partially relevant for strategic alliances. More recently, cooperative R&D as one particular form of strategic alliances was analyzed in a number of papers (cf. *Ordover/Willig, 1985, Vickers, 1985, Katz, 1986, Grossman/Shapiro, 1986, D'Aspremont/Jacquemin, 1988, Beath et al., 1988*). *Reynolds/Snapp (1986)* examined the effects of joint ventures through partial ownership in rivals on the outcome of a *Cournot* oligopoly.

To show the commitment value of forming a strategic alliance recent work in theoretical industrial organization can be used. Much of this literature since the late 1970s has focused on firms' commitments in the sense of *Schelling (1960)* in imperfectly competitive, mostly oligopolistic markets. In a situation of interdependence, where each competitor knows that the outcome of her actions depends on the actions of other firms, strategic moves to alter the subsequent competitive environment become relevant. To qualify as commitments, such strategic moves have to be irreversible or at least costly to reverse. This alone can guarantee that a firm will behave differently in the later stages of an interaction.

The numerous papers dealing with the issue of tying one's hands to commit to a different behavior share a common structure of two-stage models (for a brief survey see *Shapiro, 1989, pp. 381–397*). In stage 1 competitors take (strategic) actions which influence stage 2. The equilibrium concept of subgame perfectness ensures that period 1's actions form a commitment for period 2: When deciding on its optimal first-stage choice, each firm correctly anticipates and uses the outcome of stage 2 as a function of the first-stage choices. The distinction between commitment through investing and commitment through contracting provides a useful classification of these approaches to two-stage oligopoly games. Examples for the former are investment in capacity to deter entry, in a move down the learning curve, in R&D, or in a network of customers (see *Shapiro, 1989,* for detailed references). As for the latter, we can think of contracts within the firm and contracts with agents outside the firm. Inside the firm, recent work pointed to incentive contracts between owners and managers (cf. *Fershtman, 1985, Fershtman/Judd, 1987, Fershtman et al., 1991, Sklivas, 1987*) and to profit sharing contracts between owners and employees (cf. *Stewart, 1989, Welzel, 1989*). Contracts with parties outside the firm can be found, when private information is exchanged strategically among competitors (cf. *Shapiro, 1986*), or when technological knowledge is licensed to a competitor (cf. *Katz/Shapiro, 1985*).

The case of an owner writing an incentive contract for her manager is particularly interesting for this paper. The literature shows that an owner of an oligopolistic firm can increase her well-being by employing a manager who plays the oligopoly game on behalf of the owner. In what could be called a strategic design of a principal-agent relationship, the owner imposes an objective function on the manager which differs from her own. This is an example where it pays to delegate power to another person. The manager, however, is still part of the firm. In this paper it will be shown, that it can even be beneficial to delegate power to one's own competitor. In fact, this appears to be an important ingredient of so-called strategic alliances. It will be argued, that it is this particular feature that makes such an alliance "strategic" from the perspective of theoretical industrial organization.

The paper is organized as follows: In section 2 a simple two-stage oligopoly model is used to clarify the strategic effects of forming a strategic alliance. It will be shown that it can be beneficial to delegate power to a competitor. Section 3 addresses issues of designing an optimal contract between the firms of the alliance.

2 Strategic Effects of Delegation

For our model we draw on a specification used by *D'Aspremont/Jacquemin (1988)* to analyze cooperative R&D in a *Cournot* duopoly. To examine the strategic effects of delegating power in an alliance, the model is extended by assuming that there are three oligopolists producing a homogeneous good. Denote by $x_i, i = 1,2,3$, firm i's output. Price p of the good is a linear function of aggregate output x:

$$p(x_1, x_2, x_3) = \alpha - \beta \sum_{i=1}^{3} x_i = \alpha - \beta x. \tag{1}$$

Assume $\alpha, \beta > 0$ and $x \leq \alpha/\beta$ to hold. We consider a standard two-stage oligopoly model. Before deciding on its output x_i in stage 2, each firm i has to determine a level f_i of R&D activity. Spending money on R&D is assumed to buy a cost reducing process innovation with certainty. Producer i's cost function is given by

$$c_i(x_i, f_i) = (a_i - f_i)\, x_i + \frac{f_i^2}{2}, \qquad i = 1,2,3. \tag{2}$$

Assume $0 < a_i < \alpha$ and $f_i < a_i$. The price of one unit of R&D is set to 1. The convexity of $c_i(x_i, f_i)$ in f_i should be interpreted as expressing diminishing returns of the underlying R&D production function. In both stages of the oligopoly game producers act simultaneously as *Cournot* competitors. Note that irreversible R&D decisions can be interpreted as strategic moves before the output game. In the sequel, however, our interest is focused on the fact that forming an alliance between two firms also works as a strategic move. To examine issues of delegation of power, we assume that firms 1 and 2 sign an enforcable contract concerning cooperative R&D in stage 1 of the game. In the output game, however, they will act as competitors. The contract specifies which one of firms 1 and 2 is to carry out the common R&D project and how the costs will be shared. The firm which is designated to run the alliance's research program is absolutely free in determining the extent of common R&D. Let f denote the level of R&D activity chosen by the alliance. Under the R&D production function implicit in (2), f will cause R&D expenses of $f^2/2$. Given a share parameter $\mu \in [0,1]$, firms 1 and 2 contribute to the R&D program according to $\mu f^2/2$ and $(1-\mu)f^2/2$, respectively.

As for the outcome of the R&D project, both partners are assumed to benefit in the same way and independently of their contribution to the budget. The cost functions (2) of firms 1 and 2 are then replaced by

$$c_1(x_1, f, \mu) = (a_1 - f)x_1 + \mu\frac{f^2}{2}, \tag{3}$$

$$c_2(x_2, f, \mu) = (a_2 - f)x_2 + (1-\mu)\frac{f^2}{2}. \tag{4}$$

Note that our specification of cooperative R&D for process innovation does not imply identical production functions for firms 1 and 2. The partners in the alliance only share the technological improvements generated by the R&D project. It can easily be verified, however, that our conclusions do not change, if firms 1 and 2 possess identical technologies ex post.

In stage 2 the firms choose output levels x_i for given R&D levels to maximize profits

$$\pi_i(x_1, x_2, x_3; \mu, f) = p(x_1, x_2, x_3)x_i - c_i(x_i, f, \mu), \qquad i = 1, 2, \tag{5}$$

$$\pi_3(x_1, x_2, x_3; f_3) = p(x_1, x_2, x_3)x_3 - c_3(x_3, f_3). \tag{6}$$

Both the second-order and the stability conditions for a three-firm oligopoly as presented in *Dixit (1985)* hold as long as $\beta > 0$. (5) and (6) lead to the following reaction functions in the output game

$$x_i(x_{-i}) = \frac{1}{2\beta}(\alpha - \beta x_{-i} - a_i + f), \qquad i = 1, 2, \tag{7}$$

$$x_3(x_{-3}) = \frac{1}{2\beta}(\alpha - \beta x_{-3} - a_3 + f_3), \tag{8}$$

where a subscript "$-i$" denotes the aggregate value of firm i's competitors for a variable, i.e. $x_{-i} = x - x_i$. Solving for the *Nash* equilibrium in the output game yields

$$x_i(f, f_3) = \frac{1}{4\beta}(\alpha - 3a_i + a_{-i} + 2f - f_3), \qquad i = 1, 2, \tag{9}$$

$$x_3(f, f_3) = \frac{1}{4\beta}(\alpha - 3a_3 + a_{-3} - 2f + 3f_3). \tag{10}$$

Substituting (9) and (10) into (5) and (6) results in profit functions for stage 1 which include optimal behavior in stage 2:

$$\begin{aligned} \pi_i(f,\mu,f_3) &= p(x(f,f_3))x_i(f,f_3) - c_i(x_i(f,f_3),f,\mu), \qquad i=1,2, & (11) \\ \pi_3(f,\mu,f_3) &= p(x(f,f_3))x_3(f,f_3) - c_3(x_3(f,f_3),f_3). & (12) \end{aligned}$$

Suppose firm 1 is the one designated by the alliance to carry out the R&D program. It will choose f in stage 1 such that its profit function π_1 according to (11) is maximized. This implies for R&D

$$f = \frac{\alpha - 3a_1 + a_{-1} - f_3}{2(2\beta\mu - 1)}. \qquad (13)$$

If, on the other hand, firm 2 is the alliance's researcher, its optimal behavior requires

$$f = \frac{\alpha - 3a_2 + a_{-2} - f_3}{2(2\beta(1-\mu) - 1)}. \qquad (14)$$

Profit maximization by firm 3 which is not in the alliance is described by

$$f_3 = \frac{3(\alpha - 3a_3 + a_{-3} - 2f)}{8\beta - 9} := \rho_3(f). \qquad (15)$$

In addition to (15), (13)–(14) define reaction functions $\rho_i(f), i = 1,2$, in (f, f_3)-space:

$$\begin{aligned} \rho_1(f) &= \alpha - 3a_1 + a_{-1} - 2f(2\beta\mu - 1), & (16) \\ \rho_2(f) &= \alpha - 3a_2 + a_{-2} - 2f(2\beta(1-\mu) - 1). & (17) \end{aligned}$$

Spencer/Brander (1983) pointed to the difficulties in ensuring stability and uniqueness of the equilibrium in a two-stage model. However, given the specification used here, things turn out to be simple (for details see the Appendix). Inspection of second-order and stability conditions for the R&D game yields a set of conditions on the parameters of our model which can be summarized as

$$\mu \in \,]3/4\beta, 1 - 3/4\beta[. \qquad (18)$$

Note that the stability conditions limit the range of admissible cost sharing parameters μ. In particular, the extreme cases $\mu = 0$ and $\mu = 1$, where one partner pays for all of the alliances R&D, are ruled out. Finally, the conditions derived restrict the demand parameter β to being "not too small".

Given the stability conditions, all reaction curves $\rho_i(f)$ are negatively sloped in (f, f_3)-space. In addition, the slopes of $\rho_1(f)$ and $\rho_2(f)$ exceed in absolute value the slope of firm

3's reaction curve $\rho_3(f)$ which is in the interval $]-1,0[$. To understand the strategic value of delegating power to a competitor, assume the cost parameters to be ranked according to

$$a_1 < a_2. \tag{19}$$

It is easy to check that the ranking of a_3 relative to a_1 and a_2 does not affect the results presented in the sequel. If the inequality in (19) is reversed, our conclusions change in a straightforward way. Finally, the special case $a_1 = a_2$, where the firms in the alliance start out with identical technologies, will be addressed in section 3.

To begin with, assume that firms 1 and 2 agreed to share the costs of R&D evenly, i.e. $\mu = 1/2$, no matter which of them is chosen to carry out the R&D program. From (16) and (17) this implies identical slopes for $\rho_1(f)$ and $\rho_2(f)$. The oligopoly game can then be depicted in (f, f_3)-space as in figure 1.

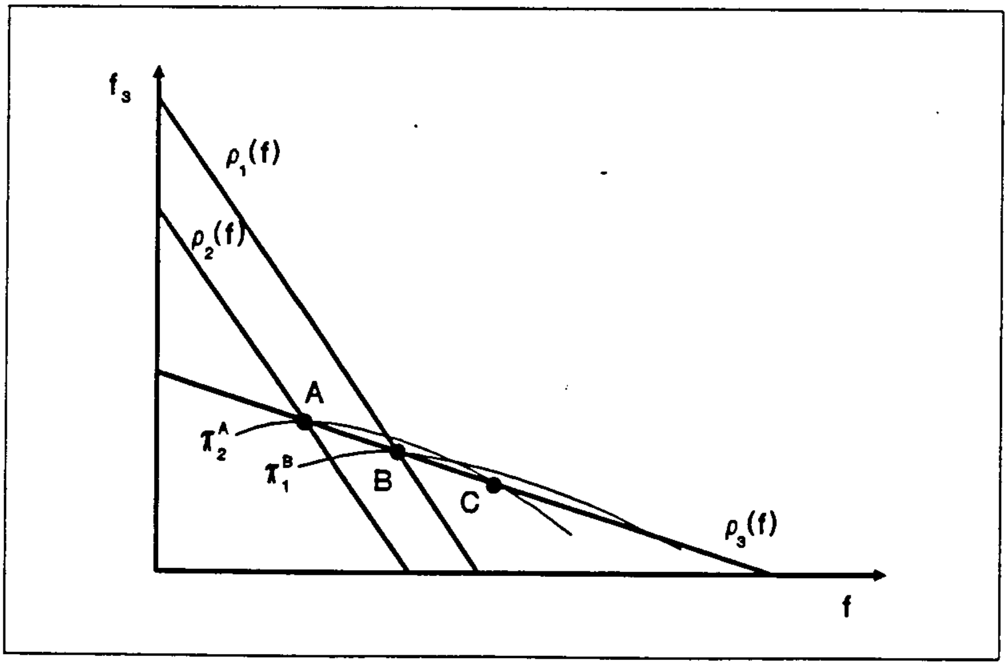

Figure 1: Equilibrium for $\mu = 1/2$ and $a_1 < a_2$.

If firm 2 were chosen to be the alliance's researcher, the oligopoly would reach its *Nash* equilibrium in point A. If, on the other hand, the power to set the alliance's R&D level f were delegated to firm 1, point B would be the equilibrium. Figure 1 is drawn under the assumption that cost parameters a_1 and a_2 are relatively similar such that $\rho_1(f)$ and $\rho_2(f)$ are not too far apart. This immediately implies that firm 2 will want to delegate R&D decisions to firm 1 since equilibrium B is located on an isoprofit contour strictly superior to π_2^A. Firm 1 will accept this offer because by delegating R&D to firm 2 it could only reach an isoprofit contour strictly inferior to π_1^B.

For the case of equal shares in the R&D budget we therefore arrive at a result similar to the one recently presented by *Gatsios/Karp (1991)* for a customs union: As long as technologies in the strategic alliance are not too different, the partner with higher production costs will want to delegate the R&D decision to the firm with lower costs which in turn has an incentive to agree with this proposal. The economics behind this conclusion can be seen from (13) and (14). By participating in the strategic alliance and accepting firm 1's decision for the optimal R&D expenses, firm 2 commits to an R&D level it could not credibly choose by itself. Note that firm 3 which remains outside the alliance faces a reduction in its profits as consequence of the delegation among firms 1 and 2.

If firms 1 and 2 are relatively dissimilar with respect to their cost parameters a_i, a conflict of interest can arise. Imagine $\rho_1(f)$ intersecting $\rho_3(f)$ to the right of point C. If this is the case, producer 2 prefers equilibrium A, whereas producer 1 prefers B. Each one of the firms wants to decide on the common R&D level. This implies that strategic alliances in R&D projects as outlined in our model are only workable as long as the participating firms are not too dissimilar.

So far, we focused on the case $\mu = 1/2$. Consider now $\mu \neq 1/2$. (16) and (17) imply that changes of μ only affect the slopes of firm 1's and 2's reaction curves in (f, f_3)–space. An increase in μ causes an increase in the slope of $\rho_1(f)$ and a decrease in the slope of $\rho_2(f)$ in absolute terms. Producer 1's reaction curve becomes steeper, whereas 2's curve becomes flatter. If, for example, in figure 1 μ is reduced below $1/2$, $\rho_2(f)$ turns to the left and $\rho_1(f)$ turns to the right with the intercept remaining constant. Point A on $\rho_3(f)$ moves leftwards, whereas point B moves in the direction of C. Both shifts tend to make the delegation of power from firm 2 to firm 1 less attractive. Inspection of the firms' isoprofit contours π_1 and π_2 exhibits changes which work in the same direction: The slope of firm 2's isoprofit contours is increased in absolute value for points to the right of $\rho_2(f)$ which moves point C to the left. If, on the other hand, firm 1's share in the budget increases above $\mu = 1/2$, $\rho_2(f)$ turns to the right and $\rho_1(f)$ turns to the left. Delegation of the power to decide on the alliances R&D expenses becomes more attractive to firm 2. The strategic alliance is more likely to be workable. Again, the changes in the isoprofit contours support this pattern. The π_2's become flatter to the right of $\rho_2(f)$, shifting point C further to the right.

Note that for high levels of the cost sharing parameter μ the incentives to delegate the R&D decisions can be reversed. Firm 1's share of the R&D budget becomes so high that it would rather have firm 2 setting a lower f for the alliance. In figure 2 $\rho_1(f)$ and $\rho_2(f)$

intersect above $\rho_3(f)$. Now producer 1 wants its partner 2 to carry out the alliance's R&D program, and firm 2 is willing to accept this offer.

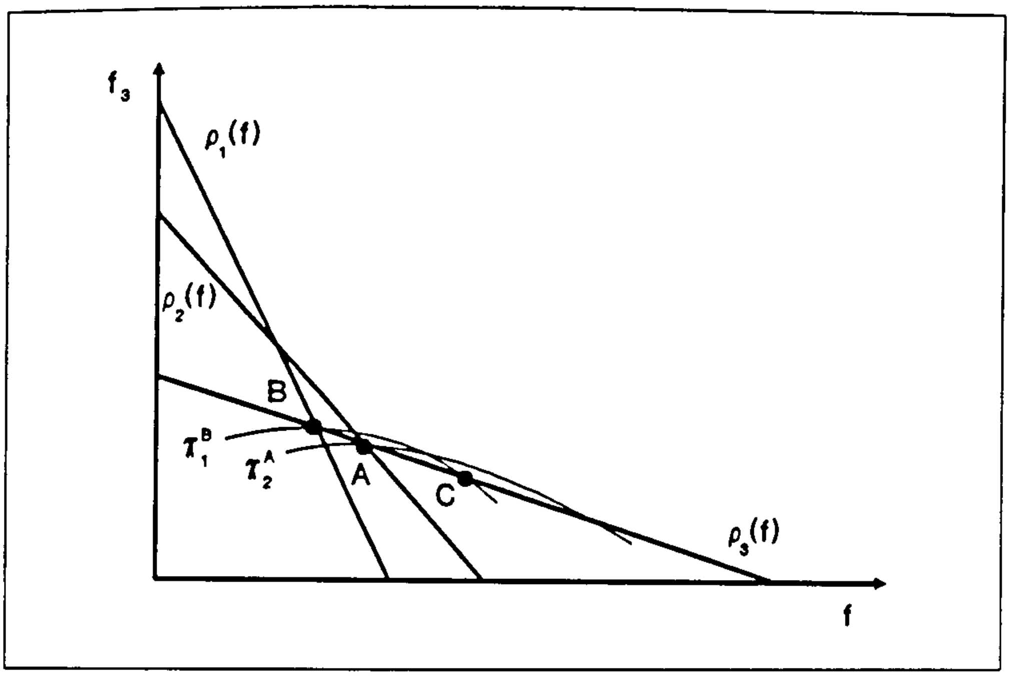

Figure 2: Reversal of delegation for large values of μ.

Consider briefly another form of strategic alliance, where firms 1 and 2 do not delegate the R&D decision to one of them, but set up a separate decision unit for the R&D project. Assume this research center is told to maximize the weighted sum of stage 2 profits π_1 and π_2. As opposed to our previous analysis which implied full delegation by one producer, this could be interpreted as a partial delegation of power by both firms. Each firm's profit function $\pi_i, i = 1, 2$, influences the objective function of the R&D decision maker. Let $\tau \in [0, 1]$ be the weight of firm 1's profit. The research center then maximizes

$$\pi_\tau(f, \mu, \tau, f_3) = \tau\pi_1(f, \mu, f_3) + (1 - \tau)\pi_2(f, \mu, f_3) \tag{20}$$

with respect to f. For $\tau = 1/2$ this is equivalent to maximizing $\pi_1 + \pi_2$. The first-order condition leads to a reaction function $\rho_\tau(f)$ in (f, f_3)-space:

$$\rho_\tau = \alpha + a_1(1 - 4\tau) + a_2(4\tau - 3) + a_3 - 2f(2\beta(\mu(2\tau - 1) + 1 - \tau) - 1). \tag{21}$$

Inspection of ρ_τ shows that for all μ permitted by (18) slope and intercept lie in intervals spanned by the slopes of ρ_1 and ρ_2 and the intercepts of ρ_1 and ρ_2, respectively. Consider e.g. the situation in figure 3, where $\mu < 1/2$ is assumed to hold. If the management of

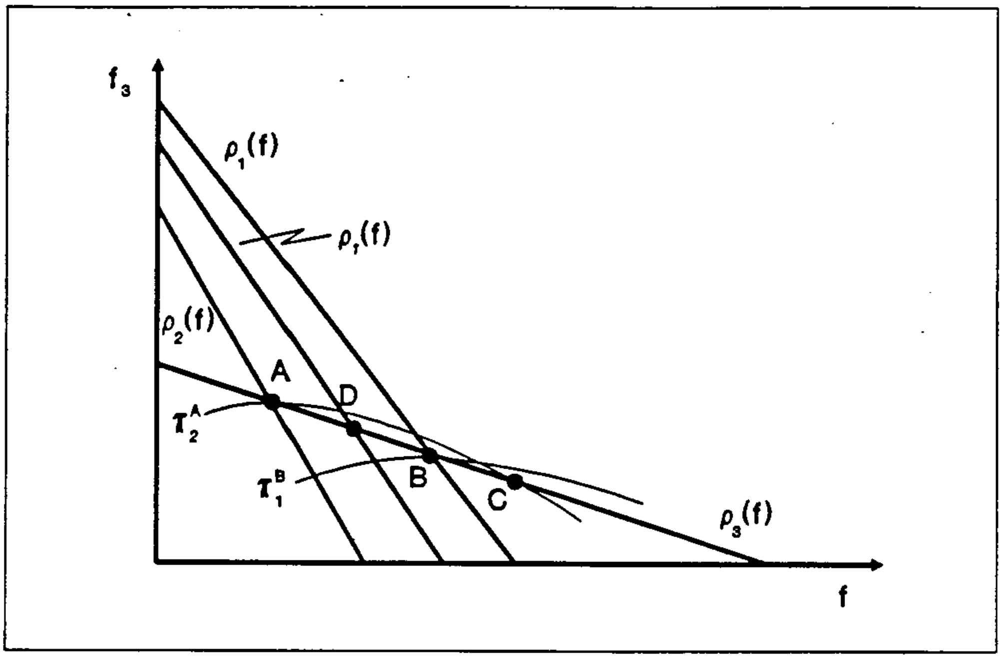

Figure 3: Equilibrium with research center maximizing $\tau\pi_1 + (1-\tau)\pi_2$.

the research center sets f according to (21), equilibrium D will arise. However, both firms prefer the delegation equilibrium B to point D. The result depicted in figure 3 readily generalizes to all admissible values of μ and τ. Our conclusions on the slope and intercept of $\rho_\tau(f)$ imply that setting up a research center to maximize a weighted sum of firm 1's and 2's profits cannot be superior and will normally be inferior to delegating R&D in the model presented here. The two firms in the alliance can do better by full delegation to one of them compared to partial delegation to a third party.

3 Optimal Design of a Strategic Alliance

So far, the alliance's cost sharing parameter μ was taken as given. Under this assumption we showed delegation among the participating firms to be *Pareto*-superior as long as their technologies were relatively similar. However, when forming an alliance, the prospective partners have to decide on the value of μ. To examine this decision, suppose now an additional stage of the game. In this stage which is played before the R&D and the output game, producers 1 and 2 reach an agreement on the delegation and set μ. It seems reasonable to assume that firms 1 and 2 act coöperatively in that stage, taking into account the consequences of their decision on the later stages of the game. Particularly, they know about the commitment value of the design of their alliance.

The best firms 1 and 2 can do is to maximize their joint profit level $\pi_1 + \pi_2$. Our previous results (16), (17) and (21) imply that the reaction function $\rho_\tau(f; \tau = 1/2)$ which corresponds to maximization of $\pi_1 + \pi_2$ in the R&D game is located right in the middle between $\rho_1(f; \mu = 1/2)$ and $\rho_2(f; \mu = 1/2)$. From *Spencer/Brander (1983)* and later work on strategic trade policy it is well-known that the most favorable position a duopolist can reach by a strategic move is that of "as-if" *Stackelberg* leadership. It delivers the profit level a *Stackelberg* leader would get given the behavior of his competitor.

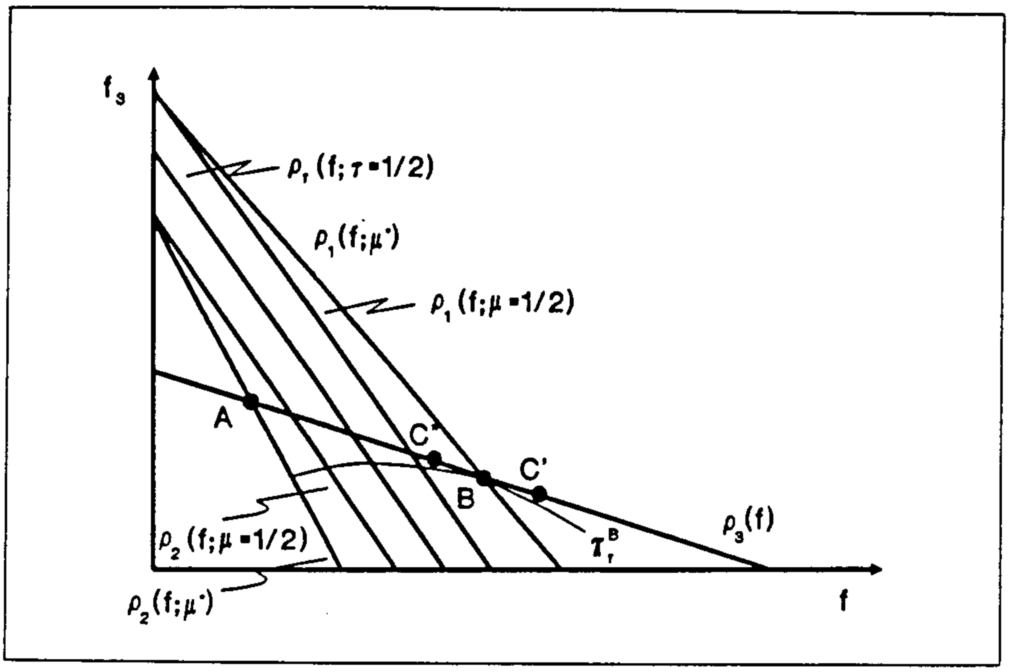

Figure 4: Choice of optimal cost sharing parameter μ^*.

Denote by π_τ the isoprofit contours for joint profits $\pi_1+\pi_2$, i.e. the contours corresponding to $\rho_\tau(f; \tau = 1/2)$. Point B in figure 4 is the alliance's most favored point in (f, f_3)-space given firm 3's optimal response $\rho_3(f)$. In B the isoprofit contour π_τ^B is tangent to $\rho_3(f)$.

Recalling our previous results on changes of μ, we are in a position to suggest an optimal choice μ^* of the cost sharing parameter. A reduction of μ below the value of 1/2 causes $\rho_1(f; \mu)$ to turn to the right. By setting μ^* such that $\rho_1(f; \mu^*)$ intersects $\rho_3(f)$ in B and delegating the R&D decision to firm 1, the alliance credibly commits to its most favorable behavior in the R&D game. Note that for point B being located to the left of the intersection between $\rho_3(f)$ and $\rho_1(f; \mu = 1/2)$ we get $\mu^* > 1/2$.

There is still the question of whether given μ^* firm 2 is willing to delegate to firm 1. To avoid cluttering the figure, firm 2's isoprofit contours π_2 are not included in figure 4. Suppose instead, C' and C" are alternative points of intersection between $\rho_3(f)$ and isoprofit contour π_2^A running through A. If C' is the relevant point, there is no conflict of interest between producer 1 and 2. If, on the other hand, C" which is to the left of B marks the intersection of $\rho_3(f)$ and π_2^A, firm 2 will prefer to set f for the alliance by itself. However, since in B joint profits $\pi_1 + \pi_2$ of the strategic alliance are maximized, the conflict of interest related to C" does not cause a substantial problem. It can easily be resolved by choosing μ^* such that $\rho_1(f;\mu^*)$ goes through B, delegating the decision to firm 1, and using a lump sum payment from producer 1 to producer 2 as compensation.

The same logic applies to a problem not explicit in figure 4: We did not address the issue of whether a firm will do better by participating in the alliance given the alliance's optimal choice of μ^* than by remaining independent and choosing its own R&D level. Again, it has to be pointed out that the partners in the alliance can set μ^* strategically to maximize their joint profit level, and can use a lump sum transfer to ensure *Pareto* superiority of their contract. Note finally that it is even possible for the alliance to reach its most favored equilibrium B by using a reversed delegation decision as depicted in figure 2 and choosing a very large value of μ^*. Given a suitable compensating payment among firms 1 and 2 the alliance in principle can use its commitment power by delegating to either one of the two partners. Nevertheless, delegation to the technologically superior firm 1 appears to be the more natural solution, since it implies less compensation and a lower risk of μ^* violating the restriction (18) on the parameters of our model.

The analysis of this section also provides insights for the special case of $a_1 = a_2$ not considered so far. Even if firms with identical technologies decide to form a strategic alliance for R&D, there is a commitment value to this decision. For $a_1 = a_2$ the reaction curves $\rho_\tau(f;\tau = 1/2)$, $\rho_1(f;\mu = 1/2)$ and $\rho_2(f;\mu = 1/2)$ in figure 4 are identical. However, setting $\mu < 1/2$ again turns firm 1's reaction curve to the right and firm 2's curve to the left. By choosing μ optimally, the alliance can reach equilibrium B.

As for the algebraic value of the optimal cost sharing parameter, μ^* can be derived for the case of firm 1 being the alliance's researcher by solving the system

$$\frac{\delta\pi_\tau(f, f_3; \tau = 1/2)}{\delta f} = \frac{d\rho_3(f)}{df}, \tag{22}$$

$$\pi_\tau(f, f_3; \tau = 1/2) = \rho_3(f) \tag{23}$$

for (f, f_3), substituting the solution into the definition (16) of $\rho_1(f)$, and solving for μ. Since the procedure turns out to be rather tedious and does not provide new insights, we restrict our analysis to the qualitative results presented so far. Note, however, that firms 1 and 2 would have to check their optimal μ^* against the restriction (18) on μ known from the previous section. If μ^* is outside the interval of admissible values, the producers have to solve a second-best problem.

4 Conclusion

Our analysis pointed to the strategic value of delegating the power for a stage 1 decision of a two–stage oligopoly game to a competitor. By forming a strategic alliance prior to the game, two firms make a credible commitment. Such a strategic move alters their competitor's expectation about their subsequent optimal actions which in turn changes this firm's optimal behavior in a way favorable to the alliance. From the perspective of theoretical industrial organization this can be seen as an economic mechanism which justifies the adjective "strategic" for recently popular strategic alliances.

Using a very simple and highly stylized model with R&D and output decisions, insights both on the extent of delegation and the design of financial relations between the partners in the alliance could be gained. Full delegation of the stage 1 decision was found to be superior to partial delegation, and a way to derive an optimal cost sharing parameter for the partners in the alliance was outlined. The principal results can be expected to be robust in a more general specification as can be seen e.g. by adapting *Spencer/Brander (1983)*.

There are clearly a huge number of economic issues relevant to strategic alliances not covered by our model. In particular, we did not deal with the important issue of which of the three firms in the market should be in the alliance (for this problem see *Morasch, 1990*). A matter that immediately comes to one's mind when delegation of power among competitors is analyzed is the problem of moral hazard. In this paper, moral hazard was assumed to be non–existent. A more realistic setting, however, would have to include stochastic R&D outcomes and non–observable actions of the alliance's researcher. The firm carrying out the R&D project for the alliance would then have an incentive to choose sub–optimal R&D efforts and blame bad outcomes on adverse stochastic shocks. When designing a contract, the partners in the strategic alliance would need to use a sharing parameter not only to gain a strategic advantage in the oligopoly game, but also to tackle the moral hazard problem within the alliance.

Appendix

To analyze stability in the R&D game, we have to distinguish between firm 1 playing against firm 3, and firm 2 playing against firm 3. Consider first the former case:

Examination of the usual adjustment mechanism (cf. *Dixit, 1985*) leads to a matrix of partial derivatives of perceived marginal profits. Denote perceived marginal profits

$\partial\pi_j/\partial f, j = 1, 2$, and $\partial\pi_3/\partial f_3$ by $\gamma_i, i = 1, 2, 3$. The relevant matrix for firm 1 and 3 can then be written as

$$\Gamma = \begin{pmatrix} \partial\gamma_1/\partial f & \partial\gamma_1/\partial f_3 \\ \partial\gamma_3/\partial f & \partial\gamma_3/\partial f_3 \end{pmatrix}. \tag{A.1}$$

Necessary and sufficient conditions for stability are trace $\Gamma < 0$ and det $\Gamma > 0$. If this is to hold independently of the adjustment speeds, we need

$$\frac{\partial\gamma_1}{\partial f} < 0, \qquad \frac{\partial\gamma_3}{\partial f_3} < 0, \tag{A.2}$$

which is identical to the second-order conditions. (A.2) implies

$$\mu > \frac{1}{2\beta}, \qquad \beta > \frac{9}{8}. \tag{A.3}$$

A sufficient condition for det $\Gamma > 0$ is that the own effects on perceived marginal profit γ_i dominate the competitor's effect, i.e.

$$\frac{\partial\gamma_1}{\partial f} < \frac{\partial\gamma_1}{\partial f_3}, \tag{A.4}$$

$$\frac{\partial\gamma_3}{\partial f_3} < \frac{\partial\gamma_3}{\partial f}, \tag{A.5}$$

since all effects are negative in our model. From (A.4) and (A.5) we get

$$-\frac{2\beta\mu - 1}{2\beta} < -\frac{1}{4\beta} \quad \Rightarrow \quad \mu > \frac{3}{4\beta}, \tag{A.6}$$

$$-\frac{8\beta - 9}{8\beta} < -\frac{3}{4\beta} \quad \Rightarrow \quad \beta > \frac{15}{8}. \tag{A.7}$$

Going through the same kind of analysis, if firms 2 and 3 are the players in the second-stage game, provides two additional conditions:

$$\mu < 1 - \frac{1}{2\beta}, \qquad \mu < 1 - \frac{3}{4\beta}. \tag{A.8}$$

Selecting those conditions which are binding we arrive at

$$\mu \in \left] \frac{3}{4\beta}, 1 - \frac{3}{4\beta} \right[. \tag{A.9}$$

As for the demand parameter β the conditions derived together imply

$$\beta > \max\left[\frac{15}{8}, \frac{3}{4\mu}, \frac{3}{4(1-\mu)}\right]. \tag{A.10}$$

In the paper we assume the value of β to be sufficiently high to meet (A.10).

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