Research Joint Ventures and R&D Cartels

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Purpose

- We analyze the effects of R&D cartelization and research joint ventures on firms that engage in either Cournot or Bertrand competition in their product market

Concerns of R&D Cartelization

- The participating firms in an RJV will tend to "free ride" on each other or curtail competition in other phases of their interaction.
- The worst possible case would occur if the research joint venture led to reduced development as compared to noncooperative R&D and product prices rose as a result of the participants' curtailing competition.

How to achieve the alleged advantages of an RJV while avoiding the potential disadvantages?

- We address these questions by analyzing four alternative scenarios.
- Each is modeled as a two-stage noncooperative game with n firms participating as players.
- In the second stage of our games the firms are assumed to engage in either Cournot or Bertrand competition, while in the first stage they invest in R&D.

The Four Scenarios

Model	First stage (R&D)	Second stage (production)
R&D competition (case N)	Firms compete; each firm decides its own R&D level given R&D investments of other firms	Firms compete; marginal cost of production is decreased by the firm's own R&D effects, in addition to some spillover from other firms' R&D
R&D cartelization (case C)	Firms coordinate their R&D activities so as to maximize sum of overall profits	Firms compete; marginal cost of production is decreased by the firm's own R&D efforts, in addition to some spillover from other firms' R&D; the spillover is not increased because of the cartelization
RJV competition (case NJ)	Firms compete; each firm decides its own R&D level given R&D investments of other firms; firms share R&D efforts and avoid duplication of R&D activities	Firms compete; marginal cost of production is decreased by the sum of all R&D efforts in the industry (spillover increased to its maximum level)
RJV cartelization (case CJ)	Firms coordinate their R&D activities so as to maximize the sum of the overall profits; firms also share R&D efforts and avoid duplication of R&D activities	Firms compete; marginal cost of production is decreased by the sum of all R&D efforts in the industry (spillover increased to its maximum level)

Externalities

- Competitive-advantage externality. -A firm deciding on its R&D investment level takes into account the effect it will have on its competitors' efficiency. It realizes that if for every dollar it spends on R&D some spills over to its competitors, reducing their unit costs, it makes them tougher competitors.

  This externality inhibits a firm's R&D spending. It is taken into account by the firms in all our models.

- Combined-profits externality. -This externality, which can be either positive or negative, is the one conferred by a firm's R&D expenditure on the profits of all the firms.

  This externality is ignored by a firm under R&D competition but is internalized when firms choose how much to spend to maximize an R&D cartel's combined profits.

Previous Work

d by Claude d'Aspremont and Alexis Jacquemin (1988)

- They considered a two-stage game: in the first stage, two identical firms conduct research leading to a reduction in unit cost, and the firms are Cournot competitors in the second stage.The focus of their analysis is on the comparison of the magnitude of cost-reducing technical advance achieved when firms conduct R&D competitively versus cooperatively, in the presence of spillover effects.Even when firms conduct R&D cooperatively, d'Aspremont and Jacquemin suppose that information-sharing remains the same as when it is conducted competitively (i.e., the spillover effect is the same in either case).
- We distinguish between the possibility of R&D coordination, information-sharing, or both.We also extend the model to more firms than two, a general concave R&D production function, differentiated products, and Bertrand price competition in the product market

Model

(1) $P_i = a - Q_i - \gamma \sum_{j \neq i} Q_j$

(2) $X_i = x_i + \beta \sum_{j \neq i} x_j \qquad i \in \mathbb{N}.$

(3) $X_i = \sum_{j \in \mathbb{N}} x_j \qquad i \in \mathbb{N}.$

For competitive R&D

For cartelized R&D

Where x_i is firm i's investment in R&D and unit cost is c – f(X_i)

ASSUMPTION 1: The R&D production function f(X) is twice differentiable and concave, f(0) = 0 and f(X) ≤ c, f'(X) > 0 for all X ≥ 0

ASSUMPTION 2: *The R&D production function f(X) satisfies*

(i) $\lim_{x \to \infty} f(X) < \frac{a-c}{n-1}$

and

(ii) $f'(0) > \frac{(n+1)^2}{2(a-c)}.$

Model

$$(4) \qquad \lim_{X \to \infty} f'(X) = 0$$

Note that monopoly profit is $[a - c + f(X)]^2/4 - X$

ASSUMPTION 3: Monopoly profit minus R&D expenditure is a strictly concave function for $X \geq 0$, or equivalently, its derivative $[a - c + f(X)]f'(X)$ decreases in X for $X \geq 0$

Our Four Scenorios

- With Cournot competition our profit function is

(5) $$\pi_i = Q_i^2 - x_i$$

where

(6) $$Q_i = \frac{a - c + f(X_i) - \frac{\gamma}{2-\gamma}\sum_{j \neq i}[f(X_j) - f(X_i)]}{2 + \gamma(n-1)}$$

R&D Competition (Case N)

- We maximize (7) π_i wrt x_i

$$(8)\quad \frac{\partial \pi_i}{\partial x_i} = \frac{2Q_i}{[2+\gamma(n-1)](2-\gamma)} \times \left[(2-2\gamma+\gamma n) f'(X_i) - \beta\gamma \sum_{j \neq i} f'(X_j)\right] - 1 = 0 \qquad i \in \mathbb{N}.$$

- We consider symmetric solutions only, that is, $X_i = X^N$ (N stands for noncooperative Nash) for all i. From (8) and (6) we obtain

$$(9)\quad \frac{2\left[a-c+f(X^N)\right]}{[2+\gamma(n-1)]^2(2-\gamma)} f'(X^N) \times [2-\gamma+\gamma(n-1)(1-\beta)] = 1$$

R&D Cartelization (Case C)

The problem solved by the cartel in this case is equivalent, in terms of the first-order condition, to each firm solving

$$(10) \qquad \max_{x_i} T = \sum_{j \in N} \pi_j$$

where π_j is given by (5), Q_j by (6), and X_j by (2)

$$(11) \qquad \frac{\partial T}{\partial x_i} = \frac{2}{[2+\gamma(n-1)](2-\gamma)} \left\{ Q_i \left[(2-2\gamma+\gamma n) f'(X_i) - \beta\gamma \sum_{j \neq i} f'(X_j) \right] + \sum_{j \neq i} Q_j \left[\beta(2-2\gamma+\gamma n) f'(X_j) - \gamma f'(X_i) - \sum_{k \neq j, k \neq i} \gamma\beta f'(X_k) \right] \right\} - 1 = 0 \qquad i \in N$$

Assuming symmetry, namely, $X_i = X^c$ (C stands for collusive) for all $i \in N$

$$(12) \qquad \frac{2\left[a-c+f(X^C)\right]}{[2+\gamma(n-1)]^2(2-\gamma)} f'(X^C) \times \{(2-\gamma)[1+\beta(n-1)]\} = 1$$

The relationship between the first-order necessary conditions if firms choose their research expenditures to maximize only their individual profits, expression (8), and compare this to the conditions when they maximize combined profits, expression (11)

We get

$$(13) \quad \frac{\partial T}{\partial x_i} = \frac{\partial \pi_i}{\partial x_i} + \sum_{j \neq i} \frac{\partial \pi_j}{\partial x_i} \qquad i \in \mathbb{N}$$

$\sum_{j \neq i} \frac{\partial \pi_j}{\partial x_i}$ is the combined profits externality conferred by firm i's R&D expenditure on the profits of all the other firms. It is added to the negative competitive-advantage externality that the firm's R&D effort has on its own profit, through reducing the marginal costs of its competitors. It is this externality, positive or negative, that is ignored when each firm chooses its R&D expenditure to maximize only its own profit and that is internalized when the firms coordinate their individual R&D expenditures to maximize the sum of their profits

Now for the symmetric equilibria expressed by (9) and (12) the externality term is

$$(14) \quad \sum_{j \neq i} \frac{\partial \pi_j}{\partial x_i} = \frac{2[a-c+f(X)]}{[2+\gamma(n-1)]^2(2-\gamma)} \times f'(X)(n-1)(2\beta-\gamma)$$

- The externality one firm's research expenditure confers upon the others is positive if and only if $\beta > \gamma/2$
- If the spillover effect is small, then the unit cost reduction experienced by the other firms because of an increase in firm i's R&D expenditure is not large enough, compared with the unit cost reduction realized by firm i, to avoid reducing their profits
- If the spillover effect is sufficiently large ($\beta > \gamma/2$), then all firms' profits rise because total equilibrium profits increase with a reduction in unit costs and the market share of the firms other than firm i does not decline significant

RJV Competition (Case NJ)

The spillover parameter $\beta = 1$.

Firms do not coordinate their R&D expenditures; each firm simultaneously chooses its R&D investment to maximize its own profits given the R&D expenditures of all other firms.

The problem solved here is (7) with $\beta = 1$. $X_i = X^{NJ}$ (NJ stands for Nash joint venture) for all i in (8), we get

$$(15) \quad \frac{2[a-c+f(X^{NJ})]}{[2+\gamma(n-1)]^2(2-\gamma)} \times f'(X^{NJ})[2-\gamma]=1$$

RJV Cartelization (Case C)

They coordinate their R&D expenditures to maximize combined profits. The problem solved here is (10) with $\beta = 1$ and $X_i = X^{CJ}$ (CJ stands for collusive joint venture) for all i in (11), we obtain

$$(16) \quad \frac{2\left[a - c + f(X^{CJ})\right]}{[2 + \gamma(n-1)]^2(2-\gamma)} \times f'(X^{CJ})[(2-\gamma)n] = 1$$

Comparison of Models

PROPOSITION 1

The equilibrium effective R&D investments, X^L, for L = N, C, NJ, CJ, satisfy the following for all β

1. $X^{CJ} \geq X^{C} \geq X^{NJ}$
2. $X^{CJ} \geq X^{N} \geq X^{NJ}$
3. $X^{C} \geq X^{N}$ if and only if $\gamma \geq 2\beta$

Free-rider

- In RJV competition, when deciding its R&D investment level, the firm takes into account the large spillover effect it will obtain (and induce) and therefore free rides on other firms' R&D investments
- We show that when firms invest in R&D according to what is prescribed by R&D competition model N, and firm i observes an increase in the value of the spillover parameter β then, if all other firms ($j \neq i$) do not change their R&D investments, it finds it best to free ride on its rivals and to decrease its R&D expenditure

COROLLARY 1

For all β the equilibrium technological improvements f(X) satisfy

$f(X^{CJ}) \geq f(X^{C}) \geq f(X^{NJ})$

$f(X^{CJ}) \geq f(X^{N}) \geq f(X^{NJ})$

$f(X^{C}) \geq f(X^{N})$ if and only if $2\beta \geq \gamma$

Let

$$Q^{\ell} = \frac{a - c + f(X^{\ell})}{2 + \gamma(n-1)} \qquad (18)$$

$$\ell = \mathrm{N, C, NJ, CJ}$$

$Q^{CJ} \geq Q^{L}$ for L = N, C, NJ

COROLLARY 2

For all β, the equilibrium prices, P^L, $L = N, C, NJ, CJ$, satisfy

$P^{CJ} \leq P^{C} \leq P^{NJ}$

$P^{CJ} \leq P^{N} \leq P^{NJ}$

$P^{C} \leq P^{N}$ if and only if $\gamma \leq 2\beta$

PROPOSITION 2

The individual firm's equilibrium profits satisfy

$\pi^{CJ} \geq \pi^{L}$ for L = N, C, NJ

$\pi^{C} \geq \pi^{N}$

Conclusion

- RJV competition is the least desirable because it leads to the lowest equilibrium technological improvement and the highest product price
- RJV cartelization was found to be the most desirable because it yields both the highest firms' profits and lowest product prices
- From Proposition 1 it follows that, if R&D requires a minimum investment in order to be effective at all, then there may be cases in which it will be undertaken by an RJV but not by the firms acting individual