4. Multicontact Collusion in Product Markets and Joint R&D Ventures: The Case of the Information Technology Industry in an Integrating Europe

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4.1 INTRODUCTION

European integration is expected to increase competition in the European markets by breaking down trade barriers. Some aspects of the integration process, however, may give rise to new forms of oligopoly and collusion. This chapter points especially to joint R&D programmes which provide opportunities for firms to meet one another, which may facilitate collusion. Tacit collusion is usually related to the internal conditions of a market. For instance, in a market with a small number of incumbent firms, each firm recognizes that its actions induce reactions by rivals. Fear of retaliation facilitates tacit collusion, which, for example, raises prices. Many firms, however, are multimarket firms. Mutual awareness and collusion may spill over to the other markets where they meet; this is the core idea of the multimarket collusion theory.¹

Joint R&D projects also offer occasions where firms meet and, perhaps, learn to coordinate their interests. The 1980s witnessed a considerable increase in the number of private (that is, non-subsidized) technology alliances (Hagedoorn and Schakenraad, 1993). In addition, the number of cooperative R&D projects financed by the EC skyrocketed in the second half of the 1980s (Roscam Abbing and Schakenraad, 1991). This means that firms not only face multimarket contacts, but also are increasingly engaged in multiproject encounters. This facilitates collusion by offering firms an additional means of retaliating defection. This argument extends the multimarket collusion theory to a multicontact collusion theory.
The European Commission, therefore, faces a policy trade-off. On the one hand, it attempts to improve competition throughout the EC by breaking down trade barriers and implementing a tougher anti-trust policy. On the other hand, it intends to raise R&D in Europe by stimulating R&D cooperation, which may facilitate collusion. This chapter explores the policy trade-off by focusing on the interaction between joint R&D projects and product market conduct (competition or collusion).

The chapter purports to explore this field rather than to present definitive results. We will first give an overview of the relevant literature on international trade, multimarket contact and joint R&D projects (section 4.2). A simple model demonstrates the reciprocal links between a number of joint R&D projects and product market collusion (section 4.3). To what extent European joint R&D projects weaken competition in the EC is an empirical question beyond the scope of this chapter. We do give a review of empirical work done by MERIT which presents data about the intensity of contact between European firms in these projects (section 4.4). From our point of view, these data raise the question of whether the large number of R&D projects, especially in the information technology industries, has contributed to a European information technology oligopoly. The chapter concludes with a discussion of the policy trade-offs faced by the European Commission (section 4.5) and an appraisal (section 4.6).²

4.2 LITERATURE ON MULTIMARKET COLLUSION

Edwards (1955, p. 335) first discussed multimarket collusion:

The interests of great enterprises are likely to touch at many points, and it would be possible for each to mobilize at any one of these points a considerable aggregate of resources. The anticipated gain to such a concern from unmitigated competitive attack upon another large enterprise at any point of contact is likely to be slight as compared with the possible loss from retaliatory action by that enterprise at many other points of contact. ... Hence there is an incentive to live and let live, to cultivate a cooperative spirit, and to recognize priorities of interest in the hope of reciprocal recognition.

It is, ironically, the great competitive strength of conglomerate (large and diversified) firms, plus their awareness of this, which prompts tacit collusion. Edwards (1955) goes on to argue that contact can arise in multiple fields: regional markets, product markets, vertical stages of production and technological partnerships. He states, for example (1955, p. 344), that:
technological partnerships tend to grow into complex systems of mutual accommodation among large business enterprises, within which the permissible sphere of activity of each enterprise is defined with ever-increasing precision as one agreement after another establishes a boundary, or a mutually satisfactory joint occupancy, between that enterprise and some other enterprise with reference to additional products and additional markets.

Edwards therefore suggests that R&D cooperation may spill over to eliminate competition in the product market. Recent theoretical contributions that, more or less explicitly, deal with the issues raised by Edwards (1955) are found in the literature on international trade (subsection 4.2.1), multimarket contact (subsection 4.2.2) and joint R&D projects (subsection 4.2.3). We discuss these contributions separately, although we recognize that some overlap exists in practice. In order to analyse the connection between joint R&D projects and product market collusion, we need to cut across these three streams in the literature (subsection 4.2.4).

4.2.1 International Trade

Recent literature on international trade emphasizes the role of imperfect competition and oligopolistic interaction. Firms' awareness of their interdependence may facilitate tacit collusion. This argument has been recognized by a number of authors such as Davidson (1984) and Rotemberg and Saloner (1989), who address the topic of one-sided imports into a home country. The effect of the home government's trade policy - such as quotas or tariffs - depends on how it influences any ongoing collusion between the home firm(s) and the importer(s). Since low quotas and high tariffs cripple the importer, they may reduce competition and thus raise domestic prices. However, they also reduce the importer's ability to punish defection by the domestic firm, and may thus weaken a cartel existing between them. To that effect, quotas and tariffs can be pro-competitive.

Pinto (1986) explores two-way trade by analysing a repeated game version of Brander and Krugman's (1983) reciprocal dumping model. The model features a standard Cournot duopoly in two-country markets, with two firms having a home base in each country. In the absence of collusion, reciprocal dumping occurs. Each firm exports to the other market, where it accepts a lower profit margin than in its home market (because of transport costs and tariffs), thus reducing both its own profits and that of the local firms. If the firms repeat the game, they may solve this Prisoners' Dilemma by maximizing joint profits (that is, through implicit collusion). They may agree on spheres of influence, where both firms decide not to export and stay domestic (Scherer, 1980). Pinto (1986) finds that infinite repetition, a low discount rate and high transportation cost or
tariffs, facilitate (implicit) collusion.

The main results of this literature, keeping its assumptions in mind, can be summarized by:

proposition 1: In a two-country setting (implicit) collusion is facilitated by (A) infinite repetition in conjunction with low discount rates, and (B) 'small' tariffs, 'large' quotas and large exporting costs with Cournot competition.

Proposition 1(A) is the standard supergame result, whereas proposition 1(B) introduces international trade specifics.

We now turn to the literature which more directly builds upon Edwards's (1955) work.

4.2.2 Multimarket Contact

Both the theoretical literature (Feinberg, 1984; Harrington, 1987; Bernheim and Whinston, 1990) and the empirical literature (Heggestad and Rhoades, 1978; Scott, 1982, 1991; Alexander, 1985; Feinberg, 1985; Feinberg and Sherman, 1985, 1988; Rhoades and Heggestad, 1985; Gelfand and Spiller, 1987) recognize that the extent of multimarket contact facilitates collusive behaviour.

In their seminal contribution, Bernheim and Whinston (1990) model the credibility of multimarket collusion in a repeated game framework. They show that in the case of symmetry of firms and markets, multimarket collusion does not arise. Their argument is that:

... once a firm knows that it will be punished in every market, if it decides to cheat, it will do so in every market. This observation raises the possibility that increasing the number of markets over which firms have contact may simply proportionately raise the costs and benefits of an optimal deviation (Bernheim and Whinston, 1990, p. 3).

Thus only in the case of asymmetry will multimarket collusion arise in situations where, in its absence, single-market collusion would not occur. Asymmetry may be due to, for example, different production costs. Symmetric cost advantages are a specific case, where each firm is most efficient in one particular product or country market. The firms collude by establishing spheres of influence. Spheres are established by shifting sales towards the more efficient firm in each market (Bernheim and Whinston, 1990, p. 13). The natural example is trade, where the domestic firm has lower costs than the importer due to the latter's transport costs and tariffs. Collusion leads to national spheres of influence (Pinto, 1986). If the
markets are different, the firms may ‘export’ the ability to sustain collusion in one market to another market where, in the absence of multimarket firms, no collusion would occur (Harrington, 1987, p. 2).

Empirical multimarket contact research seeks to verify the prediction that multimarket contact facilitates collusive conduct. The evidence gives some, albeit inconclusive, support to the multimarket hypothesis. Broadly speaking, the studies use a proxy of the intensity of multimarket contact as an explanatory variable of firms’ conduct (market share or profitability). Most find a significant multimarket contact effect. The exception is Alexander’s (1985) study of the market for short-term business loans in 69 local American banking regions in 1975. His explanation is that banks in the short-term business loans markets were subject to outside competition. The banks may have practised a ‘limit pricing’ strategy, thus forgoing profits (Alexander, 1985, p. 138). This explanation is consistent with the fact that all studies, apart from Scott (1991), are US-based with data from the 1960s and 1970s. These markets may not have been subject to foreign import competition.

Multimarket collusion occurs in conjunction with intermediate concentration levels (Alexander, 1985) or high concentration levels (Scott, 1982, 1991; Feinberg, 1985). On the one hand, Alexander (1985, pp. 131, 135) argues that concentration should be neither low (because too much competition suppresses collusion) nor high (because tacit collusion occurs in each individual market anyway) if multimarket collusion is to be facilitated. On the other hand, an overall positive correlation between multimarket collusion and concentration appears to hold (Scott, 1982; Feinberg, 1985). Scott (1991) finds that concentration raises profits if multimarket contact exists.

The main results of the theoretical and empirical studies of multimarket contact can, by and large (again keeping the imposed assumptions in mind), be summarized by:

proposition 2: If internal conditions alone fail to sustain cooperative conduct, multimarket contact facilitates collusion in markets where (A) firms and/or markets are asymmetric, (B) protection against outside competition is significant, and (C) concentration is intermediate or high.

Proposition 1(B) may be interpreted as a specific case of proposition 2(A), since tariffs, quotas and exporting costs introduce an asymmetry in favour of domestic firms. The multimarket contact studies complement the literature on single-market collusion, which points to internal market conditions (such as high concentration, infinite horizons and easy detection) by arguing that multimarket contacts sustain cooperative outcomes by
offering firms additional instruments to punish (and detect) firms which
defect from the cooperative outcome. The subsequent subsection reviews
the literature on an important instance of contacts outside the product
market: joint R&D projects.

4.2.3 Joint R&D Projects

The growth of joint R&D projects since the 1980s has inspired economists
to study the effect of R&D cooperation on technical progress, product
market competition and social welfare. The basic argument in favour
of R&D cooperation is that it enhances efficiency. Due to the public-good
character of knowledge, firms may underinvest in research activities when
they cannot capture external benefits. Cooperation may help firms to
internalize at least some of these externalities, which increases their
incentive to innovate. A cost-sharing project, where each firm has its R&D
activity subsidized by the partners in the project, allows firms to reduce
the costs of individual projects and to spread risks by engaging in more
projects (for example, Buigues and Jacquemin, 1989, p. 63).

R&D cooperation introduces a trade-off between these and other
efficiency effects and the social costs if it reduces (R&D or product
market) competition. A leading example is Katz (1986), who studies R&D
cost-sharing and cooperation in joint R&D projects. Crucial determinants
of the incentives to cooperate are the size of inter-firm R&D spillovers
and the nature of product market conduct. On the one hand, cooperation
implies that the outcome of R&D spills over to the partners. Since R&D is
a public good, partners have the opportunity to free-ride by underinvesting
in R&D and benefiting from their partners’ activities. To counter this
incentive to underinvest, the cost-sharing rule provides an overinvestment
incentive, as partners subsidize part of a firm’s R&D effort. On the other
hand, the incentive to join an R&D project decreases with the intensity of
product market rivalry. The end result is that both R&D cooperation by
firms not competing in the product market and cooperation in basic
research with significant R&D spillovers raise the effective R&D level,
which in turn increases welfare. Conversely, both R&D cooperation by
competitors in the product market and R&D cooperation in development
activities with insignificant R&D spillovers, lower effective R&D and
welfare.

Ordover and Willig (1985) and D’Aspremont and Jacquemin (1988)
confirm Katz’s (1986) results in a duopoly context. Ordover and Willig
(1985), Grossman and Shapiro (1986), Jorde and Teece (1990) and
Baumol (1992) apply these results to assess guidelines for (American)
anti-trust policy. By and large, they favour a permissive approach, where
some anti-competitive effects are allowed if otherwise (excessive) product
market competition would hamper innovation. Leniency is called for, especially if know-how has a public-good character; R&D inspires strong spillovers on other firms, patent protection is imperfect, and post-innovation competition is sufficiently intense to reduce the R&D incentive of independently innovating firms. Grossman and Shapiro (1986, pp. 335-6) suggest guidelines with a two-step approach, where:

... the first step requires definition of the relevant research and product markets, and assessment of the market power of the venture participants in these markets. Any bona fide research joint venture among firms having little or no power in either market should be promptly approved. If the parents to the proposed venture do have significant power in either the upstream, research market, or the downstream, product market, then the second step in our procedure is invoked. ... When appropriability problems are substantial, as they are likely to be for basic research activities ... the venture should be sanctioned, as should any ancillary restraints judged essential to its viability.

The main results of the literature (with the usual disclaimer involving the assumptions imposed) are summarized by:

proposition 3: Joint R&D projects are facilitated by (A) large inter-firm R&D spillovers, and (B) imperfectly competitive product market conduct (a low intensity of post-introduction competition).

The importance of imperfect competition to the sustainability of joint R&D projects may provide a link to the literature on collusion in the previous subsections.

4.2.4 Multidimensional Contact

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<th>Repeated game (infinite time horizon)</th>
<th>Multimarket contact</th>
<th>R&amp;D contact</th>
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<tbody>
<tr>
<td>Trade</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td>Multimarket collison</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td>R&amp;D joint ventures</td>
<td>-</td>
<td>-</td>
<td>x</td>
</tr>
</tbody>
</table>

Key: x = present
    - = absent
The literature on international trade, multimarket contact and joint R&D projects is clearly complementary, as Table 4.1 illustrates.

A common denominator of the three literatures is that firms meeting in many periods, markets, and/or projects recognize their increased interdependence. Both the pay-off of collusion and the potential of punishment is increased. A combination of the three contributions can be usefully applied to the process of European integration with a focus on the information technology industry. The next section offers a preliminary model to explore this.

4.3 A MODEL OF COLLUSION

A model is used to derive three propositions, which partly restate propositions 1 to 3 in terms applicable to the information industry in an integrating Europe. For the sake of convenience, the model is kept simple. We use it to suggest rather than to prove the propositions. It does not claim to give an institutionally correct description of a real-world market. First, subsection 4.3.1 links product market competition to R&D motives, and subsection 4.3.2 indicates the crucial role of product market collusion. Next, subsection 4.3.3 applies the multi-contact argument to multiproject encounters in joint R&D ventures. Subsequently, subsection 4.3.4 briefly discusses the influence of outside (that is, non-European) competition.

4.3.1 Product Market Competition and R&D Motives

There are two firms, 1 and 2. Consider the case when a new product market is opened in period 1. Demand evolves through time t, such that the monopoly profit $\pi^M_t$ changes with a constant factor $g$ ($g > 1$). So:

$$\pi^M_t = \pi^M_{t-1}/(1+g),$$

(1)

where $t > 1$ and $\pi^M_t$ ($> 0$) is the first-period profit. Note that $g > 0$ indicates a declining market, whereas $g < 0$ represents growing demand.

Entry by a firm requires a fixed outlay $F$ ($> 0$) in period 0. The firms are identical and their products are perfect substitutes; the firms compete on price (Bertrand competition). They have equal unit costs and face no capacity constraints. Consumers switch to the lowest-priced supplier. In case of a tie (equal prices), they buy from the suppliers on a fifty-fifty basis. Pay-offs are as follows. If one firm enters the product market, it earns the monopoly profit $\pi^M$. The present value $P$ of the flow of profits in period 0 equals:
\[ P^M = \alpha \frac{\pi^M}{(1+r)} \tag{2} \]

where \( \alpha = \frac{[(1+r)(1+g)]}{[(1+r)(1+g)-1]} \). If \((1+r)(1+g) > 1 \) (for example, if \( r > 0 \) and \( g > 0 \)), then \( \alpha > 0 \). If two firms enter, then they compete on price. Each firm is willing to underprice slightly the competitor, thus capturing the entire market while forgoing a small profit margin. Anticipating this, each firm realizes that the unique equilibrium prices are equal to the unit (marginal) costs. This is standard Bertrand competition. Thus their gross profits are zero. The present value, \( P^B \) (\( B \) for Bertrand competition), likewise equals zero. Table 4.2 shows the pay-off matrix with net profits.

**Table 4.2** Pay-off matrix of simultaneous entry game

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<tr>
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<th>Firm 2 Enter</th>
<th>Firm 2 Do not enter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm 1 Enter</td>
<td>(-F,-F)</td>
<td>((P^M-F,0))</td>
</tr>
<tr>
<td>Firm 1 Do not enter</td>
<td>((0,P^M-F))</td>
<td>((0,0))</td>
</tr>
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Entry is feasible if the net profit is positive. That is:

\[ P^M-F > 0 \tag{3} \]

The product market is a natural monopoly: one firm can make profits \((P^M-F > 0)\), but two firms cannot \((P^B-F < 0)\). Note that the argument can be easily extended to a Cournot duopoly (if \( P^B < F \)).

There are two Nash equilibria in pure strategies, where one firm enters the product market while the other does not. Thus a unique equilibrium outcome does not exist. A supply coordination failure may arise (Smith, 1981, p. 3) if both firms enter or both rivals fail to do so. As we will see, this failure induces private or public coordination of R&D efforts. In the absence of coordination two non-cooperative solutions exist. One is the maximin solution, which implies that each firm acts on the basis of a worst-case scenario (Sherman and Willett, 1967). Each firm, fearing that its rival will enter, decides not to enter. As a result, the new product market is not served; thus both firms forgo the profit opportunity offered by the new product market. A second solution to the coordination problem is a mixed equilibrium (Nii, 1989). In the mixed equilibrium, each firm randomizes its strategy such that the other firm is indifferent about entry.
As a result, the expected pay-off is zero. Each firm decides to enter with a probability \((P_{\text{m}}-F)/P_{\text{m}}\) and to stay out with probability \(F/P_{\text{m}}\). In this equilibrium there is a positive probability that no firm enters, that either firm enters, or that both enter. The firms (optimally) anticipate the possibility of a supply coordination failure.

Both the maximin solution and the mixed equilibrium solution imply zero (expected) net profits. This is the non-cooperative outcome. Entry into the new product market is a product innovation, and the fixed outlay, \(F\), may be seen to represent an R&D budget. This is a very simple R&D model indeed, as it ignores such real-world phenomena as (technical or creative) uncertainty, R&D spillovers, patenting and diffusion. It does bring out the public-good character of knowledge, as one investment, \(F\), is sufficient to allow both firms to introduce the new product. If firms innovate independently, they completely duplicate research, which is a social waste. Although the model is simple and ignores numerous aspects of innovation, it does bring out one genuine problem: the firms are unable to prevent a supply coordination failure if they act non-cooperatively. Next, we turn to cooperation.

4.3.2 R&D Cooperation and Product Market Collusion

The motive for R&D cooperation may be cost-sharing. Cost-sharing alone, however, does not solve the above coordination problem. Say, for example, the firms share the cost \(F\) on a fifty-fifty basis. Both enter the product market. In the subsequent product market competition, both rivals will try to steal consumers away from the other by price-cutting (Bertrand competition). Since both anticipate this post-introduction competition, they quote prices with zero gross profits. Thus, the net profits are \(0-F/2\) (or, in the general case, \(P_{\text{m}}-F/2\)), which is negative (if \(P_{\text{m}} < F/2\)). Cost-sharing does not solve the problem, since post-introduction rivalry is very intense: Bertrand price-cutting competition destroys all profits. In order to recover their R&D outlays, firms must reduce the intensity of their competition. If both competitors tacitly collude not to undercut each other’s price, then they can quote the monopoly price, \(P_{\text{m}}\). If consumers buy from the firms on a fifty-fifty basis, then each firm will earn gross profits of \(\pi_{\text{m}}/2\), with a present value of \(P_{\text{m}}/2\). Since \(P_{\text{m}} > F\) (feasibility condition (3)), \(P_{\text{m}}/2 - F/2\) is positive. Thus cooperation does pay off. As a special case of proposition 3(B), joint R&D requires product market collusion. This result implies that a trade-off exists between dynamic efficiency (that is, R&D cooperation in order to avoid the supply coordination problems of deterred and duplicated R&D) and static efficiency (that is, competitive price rivalry in the product market).

Product market collusion, however, suffers from the free-rider problem.
If one firm quotes the monopoly price $p^M$, the other firm may defect by quoting a price slightly below this price (say, $p^M - \epsilon$, where $\epsilon$ is arbitrarily small). All consumers will turn to this supplier. Thus the defector earns approximately the full monopoly profit, $\pi^M$. Cooperation requires the ability of each firm to punish a defector. This is possible if competition occurs on a regular basis. Infinitely repeated market contact over time facilitates the sustainability of collusive arrangements (subsection 4.2.1: proposition 1(A)). The argument runs as follows. Defection now can be punished in the future, and can thus be deterred. If, say, firm 1 defects at period 1, it earns $\pi^M_1$ in the first period. In the subsequent periods the defector is punished by firm 2, which suspends the cooperation. They revert to the Bertrand equilibrium with zero profits and stay there forever. Thus the present value equals $\pi^M_1 / (1+r)$. The present value in the case of cooperation is $P^M/2$. Cooperation is the equilibrium outcome if

$$\alpha / 2 [\pi^M_1 / (1+r)] > \pi^M_1 / (1+r)$$

which implies:

$$1 < (1+r)(1+g) \leq 2. \quad (4)$$

If $r$ and $g$ are sufficiently large (that is, if $(1+r)(1+g) > 2$), each firm will defect if the rival offers to cooperate. Anticipating this, neither is willing to cooperate in the first place, and both prefer the Bertrand price competition outcome. Intuitively, a high rate of market decline, $g$, invites defection by implying that the cost of punishment, in the sense of future profits forgone, is small relative to the current profit (Bernheim and Whinston, 1990, pp. 8-9).

In the case of short-lived or rapidly declining markets, collusion is unlikely to occur. This result is in accordance with models studying the stability of collusion over the business cycle (for example, Rotemberg and Saloner, 1986). The results are summarized by:

proposition 4: Product market collusion - promoted by (A) infinite discounting (proposition 1(A)), and (B) growing markets - facilitates the sustainability of joint R&D (proposition 3(B)).

Proposition 4 describes the positive influence, under particular conditions, of product market collusion on the sustainability of joint R&D. The next subsection deals with the opposite causality: does joint R&D facilitate product market collusion?

4.3.3 R&D Cooperation on a Regular Basis

As an example of multicontact collusion, R&D cooperation widens the
opportunities for sustainable cooperation. By suspending all cooperation, now or in the future, punishment is made more severe, and thus more effective. First, if a firm defects, the other partner can punish in some or in all of their other current R&D projects. Firms are unlikely, however, to break off current R&D projects because of the commitments to these projects. Secondly, punishment can occur by a refusal to start new R&D ventures with a defector in the future. The prospect of multiple contacts in the future may help to sustain collusion in cases where the prospect of meeting one another repeatedly in one project is insufficient to prevent defection (subsection 4.2.2, proposition 2).

We model this intuition as follows. Say, every T (≥ 1) periods a new product appears that offers a profit opportunity to the two firms in one market. For the sake of convenience, assume that these opportunities are otherwise identical. One can think of overlapping generations of a product, examples being new generations of chips and television screens. If the firms fail to cooperate, the expected value of these projects is zero (subsection 4.3.1). If the firms succeed in cooperation, the net present value of a project at time T, 2T, 3T, ... is (PM-F)/2. The net present value of a flow of such projects in period 0 equals [(PM-F)/2]/{[(1+r)^T]/[(1+r)^T-1]}. If firm 1 defects, it earns (approximately) the monopoly profit in period 1, \( \pi_1 \). Punishment by the other firm leads to 0 profits forever. The net present value of this flow in period 1 is \( \pi_1^M \). If firm 1 cooperates from period 1 onwards, its present value in period 1 is \( (1+r)PM/2 \) for the current project, and \( \beta[(PM-F)/2] \) for the future projects, where \( \beta = [(1+r)/(1+r)^T-1] \). Firm 1 cooperates if:

\[
\alpha.(\pi_1^M/2) + \beta.[(PM-F)/2] > \pi_1^M. \tag{5}
\]

If \( (1+r)(1+g) \leq 2 \), then the left-hand side (LHS) exceeds the right-hand side (RHS) for any value of T (condition (4)). Thus in this case the ability to start other joint R&D projects in the future does not affect the motivation to cooperate. If, however, \( (1+r)(1+g) > 2 \), condition (5) allows for collusion in cases where a single R&D project would induce defection. Whether collusion will indeed occur depends upon T, that is, the lag between product innovations. The LHS decreases in T. T* is defined so that the LHS equals the RHS. Since the LHS decreases in T, we can conclude that for \( 1 \leq T \leq T^* \) collusion is possible (that is, LHS > RHS). For \( T > T^* \) collusion is unsustainable. Larger lags invite defection because they shift the reward for cooperation further into the future. If \( T^* < 1 \), collusion cannot be sustained for any T. A small T refers to a rapid succession of R&D projects, which gives:

proposition 5: A large number of successive joint R&D projects (that is, a
small T) stimulates both R&D cooperation and product market collusion.

Proposition 5 extends propositions 1 and 2 to the case where firms meet in R&D cooperation as well as in product markets. The prospect of a series of new products induces European firms both to cooperate in R&D and to collude in the product markets. There is a reciprocal causality where product market collusion facilitates joint R&D projects (proposition 4), and R&D cooperation improves the stability of (multi-) product market collusion (proposition 5).

We can interpret T as a product life cycle. The appearance of new product generations (introduced T periods apart) causes the older products to wither away (hence, g > 0). This leads to:

corollary: Short product life cycles stimulate both R&D cooperation and product market collusion.

The corollary may account for the fact that joint R&D projects, both private and public, appear in industries with short product life cycles. These are called core technologies, because they are expected to produce many new products. The information technology industry is a case in point, as we will see in section 4.4.2. The corollary points to an economic motive for cooperation in core technologies rather than a technical one (for example, exchange of complementary technologies) or a financial one (for instance, cost-sharing).

4.3.4 Competition by Non-European Firms

Proposition 2(B) points to the influence of outside competition on cooperation. In the European context this translates to the hypothesis that the prospects for European integration depend crucially on the impact of non-European firms' strategies. We will explore this effect indirectly with reference to the above models. First, consider the case where non-European firms imitate European firms. Following a European innovation in period T, the non-European firms build up market share gradually by expanding low-cost production processes. The quicker they do so, the faster they erode the profit potential of the European firms (that is, the higher g in condition (4)). Entry barriers, such as output quotas, may however deter or slow down their entry process. Thus, rapid imitation and low entry barriers together raise the rate of profitability decline (g), which facilitates defection.

Secondly, non-European firms may also be innovators. If innovation is a 'winner takes all' (patent) game, at least within the European Communi-
ty, entry by non-European innovators diminishes the number of successful innovations by European firms. This will increase the time-lag (T) between successful hits for European firms. We have seen that larger lags invite defection, as they shift the reward for cooperation further into the future. The effects in both cases of entry by imitative and innovative non-European firms are summarized by:

proposition 6: Low entry barriers to non-European firms prevent collusion by innovatory European firms through increasing g (proposition 4) and increasing T (proposition 5).

Proposition 2(B) is in accordance with proposition 6. Entry by non-European firms improves the competitive functioning of product markets. The ensuing breakdown of collusion may, however, prevent the European firms from innovating in the first place. If they go for the maximin solution, they do not innovate unless they expect to be able to cooperate in the product market. So, easy (imitative) entry by non-European firms may not be in the best interest of the European Community, a point we will return to in section 4.5.

4.4 EVIDENCE OF CONTACT

The European Commission has installed research programmes for trans-national cooperation projects to stimulate, support and finance technology alliances within Europe. During the 1980s, the absolute number of cooperative research projects increased from very few to several hundred. According to the CATI database of MERIT, the first cost-shared joint technology projects began in 1983. Until January 1990, 920 projects were ongoing; these are co-financed in the framework of the EUREKA programme and the European Community’s ESPRIT, RACE, BRIDE/EURAM and BAP/BRIDGE programmes (Roscam Abbing and Schakenraad, 1990, 1991). The programmes focus on core technologies in general and information technologies in particular, as the data in Table 4.3 reveal. Table 4.3 depicts the distribution of projects over three core technology sectors and seven European programmes between 1983 and 1989.

These research programmes may have numerous motives (see subsection 4.2.3). We recognize the genuine importance of these motives (for example, cost-sharing). Nevertheless, we want to call attention to the obvious fact that the same firms meet in numerous of these projects. As emphasized by Edwards (1955) and modelled in section 4.3, occasions for firms to meet may serve as collateral in tacit collusion in product markets.
Table 4.3  Number of projects by core technology for different European cost-sharing technology programmes in 1983-89

<table>
<thead>
<tr>
<th>Programme</th>
<th>Biotechnology</th>
<th>Information technology</th>
<th>New materials technology</th>
<th>Other projects</th>
<th>Total nr</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAP</td>
<td>33</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>33</td>
</tr>
<tr>
<td>BRITE</td>
<td>-</td>
<td>-</td>
<td>89</td>
<td>-</td>
<td>89</td>
</tr>
<tr>
<td>EURAM</td>
<td>-</td>
<td>-</td>
<td>67</td>
<td>-</td>
<td>67</td>
</tr>
<tr>
<td>ESPRIT</td>
<td>-</td>
<td>400</td>
<td>-</td>
<td>-</td>
<td>400</td>
</tr>
<tr>
<td>RACE</td>
<td>-</td>
<td>47</td>
<td>-</td>
<td>-</td>
<td>47</td>
</tr>
<tr>
<td>EUREKA</td>
<td>59</td>
<td>142</td>
<td>24</td>
<td>59</td>
<td>284</td>
</tr>
<tr>
<td>ALL</td>
<td>92</td>
<td>589</td>
<td>180</td>
<td>59</td>
<td>920</td>
</tr>
<tr>
<td>%)</td>
<td>(10)</td>
<td>(64)</td>
<td>(20)</td>
<td>(6)</td>
<td>(100)</td>
</tr>
</tbody>
</table>


This section assesses data on the extent to which European firms meet in joint R&D projects. Subsection 4.4.1 presents data on the increasing number of technology alliances world-wide and in Europe in particular. Subsection 4.4.2 specifically discusses the information technology industry.

4.4.1 Contact Through Technology Alliances

An important and intense mode of contact is the strategic alliance. A number of studies have demonstrated that the incidence of strategic alliances has increased considerably during the past decade (for example, Hergert and Morris, 1988; Hagedoorn and Schakenraad, 1993). The CATI database of MERIT presented by Hagedoorn and Schakenraad (1993) is particularly illustrative. Figure 4.1 shows that the world-wide growth of newly established technology alliances is significant, particularly during the period from 1983 to 1989. In 1989, for example, almost 600 new technology alliances were established. Note that alliances subsidised by the EC are excluded from the data.
The data in Figure 4.1 are related to the arguments in sections 4.3 and 4.4 (particularly propositions 4 and 5): the trend is clearly towards an increasing number of contacts through technology alliances - particularly in core technology industries with shortening product life cycles (Norton and Bass, 1992). Figure 4.2 shows that there is a trend towards intra-bloc technology alliances (that is, with partners from only one of the three economic blocs - Europe, Japan and the USA) rather than inter-bloc alliances (Europe-USA, Europe-Japan and USA-Japan). This is consistent with the interpretation that within each bloc, firms seek to establish an oligopoly (although it is consistent with other explanations as well). The motives for strategic (technology) partnering are diverse (Hagedoorn, 1993). The dominant motive may be market-access or technology-sharing. Over the 1980 to 1989 period, the motives for intra-bloc alliances and inter-bloc partnerships seemed to differ. Figure 4.3 depicts the data.

The motivation for intra-bloc alliances appears to be predominantly technology-based, whereas the motivation for inter-bloc partnerships is primarily one of market access. The former finding appears consistent with (among others) our point of view. The second finding is not surprising.
Market access is an important concern for non-European firms which wish to establish a foothold within the EC. This may reflect a fear of the establishment of a ‘Fortress Europe’ in the near future (van Witteloostuijn and van Wegberg, 1991). A particular case where entry does appear blocked is European joint R&D programmes, which exclude non-European firms.

4.4.2 Joint R&D Contact in the Information Technology Industry

Information technology is dominant in European joint R&D programmes. It has the largest technology programme, ESPRIT (the European Strategic Programme for Research and Development in Information Technologies). About 41 per cent of the non-EC-subsidized technology alliances in the CATI database relate to the information technology industry, and 64 per cent of the EC-subsidized R&D projects originate in this sector (Table 4.3). Detailed studies of (private and subsidized) networking in the information technology industry are found in Roscam Abbing and Schakenraad (1991) and Hagedoorn and Schakenraad (1992).
Each alliance constitutes a 'link' between any two of its participants. Data exist for the leading information technology firms which initiated the ESPRIT programme, and which cooperate in both subsidized and private R&D programmes. These participants were initially known as the 'Big 12'. Tables 4.4 and 4.5 sum up the pairwise links between the 12 (in the cells) and their contacts outside the 12 (N). The number of subsidized contacts by far dominates the incidence of private R&D links. The number of private R&D encounters outside the 12 varies from 4 (Nixdorf) to 40 (Philips). The number of private links (18) between Philips and Siemens stands out. Moreover, the number of empty cells (representing the absence of private R&D encounters) is remarkably large. The question is, of course, whether subsidized R&D links substitute for private R&D links. If they do, then they do not increase the total number of contact points. If they do not, then they raise the number of overall R&D links, which, as we hypothesized, may facilitate product market collusion (sections 4.3 and 4.4, particularly proposition 5).

The cooperating firms can further strengthen collusion by raising barriers to entry to outsiders which, by proposition 6, facilitates multi-
<table>
<thead>
<tr>
<th></th>
<th>Contacts</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEG</td>
<td>X</td>
<td>125</td>
</tr>
<tr>
<td>Bull</td>
<td>5</td>
<td>107</td>
</tr>
<tr>
<td>CGE</td>
<td>15</td>
<td>238</td>
</tr>
<tr>
<td>GEC</td>
<td>14</td>
<td>119</td>
</tr>
<tr>
<td>ICL</td>
<td>2</td>
<td>57</td>
</tr>
<tr>
<td>Nixdorf</td>
<td>4</td>
<td>52</td>
</tr>
<tr>
<td>Olivetti</td>
<td>6</td>
<td>66</td>
</tr>
<tr>
<td>Philips</td>
<td>15</td>
<td>139</td>
</tr>
<tr>
<td>Plessey</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>Siemens</td>
<td>6</td>
<td>126</td>
</tr>
<tr>
<td>STET</td>
<td>12</td>
<td>115</td>
</tr>
<tr>
<td>Thomson</td>
<td>12</td>
<td>124</td>
</tr>
</tbody>
</table>

Table 4.4  Collaboration of leading information technology firms in ESPRIT, EUREKA (IT) and RACE

Notes: 1. AEG=Daimler, ICL=STC, STET=IRI.
2. N=number of different firms with which a link exists, excluding the 11 other founding firms of ESPRIT.
3. Only information technology projects of EUREKA are selected.

### Table 4.5  Collaboration of leading information technology firms in private R&D links

<table>
<thead>
<tr>
<th>Contacts</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEG</td>
<td>X</td>
</tr>
<tr>
<td>Bull</td>
<td>1</td>
</tr>
<tr>
<td>CGE</td>
<td>6</td>
</tr>
<tr>
<td>GEC</td>
<td>2</td>
</tr>
<tr>
<td>ICL</td>
<td>-</td>
</tr>
<tr>
<td>Nixdorf</td>
<td>1</td>
</tr>
<tr>
<td>Olivetti</td>
<td>-</td>
</tr>
<tr>
<td>Philips</td>
<td>1</td>
</tr>
<tr>
<td>Plessey</td>
<td>-</td>
</tr>
<tr>
<td>Siemens</td>
<td>4</td>
</tr>
<tr>
<td>STET</td>
<td>1</td>
</tr>
<tr>
<td>Thomson</td>
<td>1</td>
</tr>
</tbody>
</table>

**Notes:**
1. AEG=Daimler, ICL=STC and STET=IRI
2. N = number of different firms with which a link exists, excluding the 11 other founding firms of ESPRIT

**Source:** MEDITCATI database reported in Roseam Abbé and Schakenraad (1991)
market collusion. Mytelka (this volume), for example, argues that during the 1980s the European information technology firms tried to substitute technological and marketing entry barriers for the traditional trade barriers which they relied on in the 1970s. Participants in an R&D programme may raise barriers by developing exclusive know-how which, for a period of time at least, is not accessible to non-participating firms. They may also raise barriers by agreeing on standards which are incompatible with standards used by non-participating firms (for instance, Farrell and Saloner, 1986). The case of high definition television is a good example. The emerging US, Japanese and European standards are incompatible, and some are not backwards compatible with current TV screens. The battle for new standards translates into a fight for market share in the future TV and related markets (The Economist, 4 August 1990).

The $64,000 question is, of course: did European information technology firms try to create a collusive oligopoly, and did they succeed? The chapter in this volume by Mytelka addresses this problem. Mytelka concludes that the joint R&D programmes in the 1980s (ESPRIT I and II) were indeed part of an attempt by the ‘Big 12’ to, ‘build a European technology-based oligopoly’. Moreover, she concludes that in the 1990s the oligopoly is crumbling.

Some firms have been taken over by non-European firms (for example, ICL by Fujitsu), others have withdrawn from at least some EC programmes (for example, Philips has all but withdrawn from the JESSI programme), and one firm, Siemens, tries to make it to the top by developing a global partnering approach. Mytelka emphasizes internal explanations of the cartel’s disintegration: the oligopoly focused too much attention on defending the European home market rather than serving a global market, and it failed to include European corporate users of its information technology. She also argues that the initial reservation (in ESPRIT I) to relate R&D to marketable products, cost the ‘Big 12’ dear in terms of competitiveness in product markets. In line with this argument, our chapter points particularly to external explanations of unsustainable collusion, especially the intense global competition by Japanese and US rivals (see proposition 6). The chapter by Duysters and Hagedoorn in this volume gives an account which is, to some extent, consistent with this. It shows that divergence rather than convergence characterizes the relationship between European, US and Japanese firms. Contrary to Mytelka’s assessment, European information technology firms are not concluded to be weaker than their foreign rivals.
4.5 POLICY TRADE-OFFS FOR THE EUROPEAN COMMISSION

The Commission of the European Community (CEC) aims at improving European competitiveness and increasing R&D efforts. The CEC faces two policy options, which can roughly be identified with industrial policy and competitive policy. The former seeks to induce European firms to coordinate their R&D efforts. As we have seen, R&D coordination reduces costly entry rivalry. Lack of coordination may instead lead to coordination failures if firms duplicate R&D or, anticipating this, do not start with R&D at all (subsection 4.3.1). The R&D cooperation may, however, both require as well as facilitate product market collusion (propositions 4 and 5). The Commission may even face the need to facilitate product market and R&D collusion by increasing barriers to non-European entry (proposition 6). Product market collusion, if this is the outcome of multiple contacts, may be the price to pay for R&D cooperation. Collusion may protect innovators much like patents create (temporary) monopoly power. To implement this policy, the CEC may use guidelines similar to those which Grossman and Shapiro (1986) propose for anti-trust policy in the USA (see subsection 4.2.3).

Competitive policy, on the other hand, entails that the CEC takes a firm anti-collusion stance. In order to suppress product market collusion, the CEC may implement a strict anti-trust policy, forbidding, if necessary, a joint R&D programme, or intervening in the terms accepted by the partnering firms (for example, membership). This may contribute to (static) efficiency, as prices fall towards marginal costs and profits move to zero. It may also, however, undermine the European firms' incentives to innovate. This policy dilemma is a variety of the well-known trade-off between static efficiency and dynamic efficiency.

As an alternative to competitive policy, the Commission may change the size of trade barriers to non-European firms. Global competition can be a lever to check intra-European collusion. If, however, the European partners in a joint R&D project have a dominant position in the world market, global competition is unable to mitigate any anti-competitive effects of R&D cooperation. A strict anti-trust policy may then be recommended. If viable non-European rivals do exist, global competition can indeed constrain intra-European collusion. European alliances may, in fact, be a defensive response to intensified global competition (for example, Thimm, 1988-1989, p. 67). The non-European firms may themselves constitute an oligopoly. In this case, global competition would diminish if European firms, such as Airbus, were eliminated. This argument favours intra-European (R&D as well as product market) cooperation in order to
provide European firms with financial means for investments without which they might be forced to exit from R&D-intensive product markets.

4.6 APPRAISAL

Where the balance between competition or collusion - on country, EC or global basis? - will appear to stabilize is an open question. This chapter concludes, however, that there are sound theoretical and empirical arguments which suggest that multicontact collusion may increase in post-1992 Europe. It seems meaningful, therefore, to recommend future research on this issue in the context of European integration. Both empirical and theoretical work may aim at systematically identifying conditions which further or impede multicontact collusion. From an empirical angle, future research may focus on providing direct evidence involving the propositions in section 4.3 by testing whether an increased number of R&D contacts (as discussed in section 4.4) goes hand in hand with increased product market collusion. From a theoretical point of view, one can extend the R&D model by allowing for R&D spillovers between firms, and one can extend the product market model by allowing for competition in quantities rather than prices, as well as competition in multiple product markets.

NOTES

2. The argument in this chapter is related to van Wegberg, van Witteloostuijn and Roscam Abbing (1994).
3. One can raise doubts about the methods used. For example, Heggstad and Rhoades (1978) indicate collusion by the stability of dominant firms' market share. The price-cost margin seems to be a better dependent variable to indicate collusion (Feinberg, 1985). As a proxy for the degree of multimarket contact, Heggstad and Rhoades (1978) use the number of contacts, that is, markets where two firms meet. Other authors employ more sophisticated methods, Scott (1982, 1991) uses as a proxy the number of contacts going beyond a random number of contacts; Feinberg (1985) weights contacts by the sales level in the markets where retaliation may occur ('sales at risk').
4. The theoretical literature does not explore the effect of outsiders. It assumes that multimarket firms compete or collude in markets where entry by outsiders is blocked (Bernheim and Whinston, 1990, p. 4).
5. A player who does not enter is chicken (a coward): hence, this game is known as the Chicken Dilemma.
6. Once in a punishment phase, the firms may try to escape from the grim trigger strategy to permanently punish defection by renegotiating a return to cooperation (Tirole, 1988, p. 253). We ignore this complication.

7. For example, if the monopoly profit declines by more than half each period (that is, if \( g > 1 \)), defection occurs for any discount rate, since then \((1+r)(1+g) > 2\) irrespective of the value of \( r > 0 \).

8. See Norton and Bass (1992), who have a model of overlapping product generations where new generations reduce demand for previous ones.

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