EIBA 2000
Maastricht Dec. 10-12, 2000

Cooperation and the Internationalization of R&D Insights from firms located in France

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Introduction

Since the 1980s, the increasing role of innovation as a factor of competitiveness in the context of globalization has stimulated technological progress and led to deep evolutions in corporate R&D practices. Firms have been pressed to increase simultaneously economies of scale, scope, speed and space.[1] When firms diversified at the beginning of the XXth century, they started to implement new structures in order to reap economies of scale and scope (Chandler 1962, 1990). Interactions between globalization, increased competition and a faster pace of innovation press firms to also increase economies of speed and space, which, in turn require new structural evolutions from firms.

Cooperative agreements and networking constitute major such organizational responses to more complex and demanding competitive environments. Since the late 1980s, the progressive implementation of global strategies has also stimulated the internationalization of R&D. This paper discusses the interactions between these two evolutions and more precisely examines the role of R&D cooperation as one of the ways to source technology abroad. The empirical tests use a French survey on R&D cooperation by firms located in France. Results confirm that firms in high tech sectors have a higher propensity to cooperate, especially with rivals. Tests on international cooperation suggest that French firms are quite keen to cooperate with American partners – rather than European ones – in high tech sectors, and especially in information and telecommunication technologies. The conclusion discusses the policy implications of this result.

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[1] O. Granstrand (1998) discusses this trend in the case of the « technology-based firm », which constitutes a growing sub-species of the modern business firm.

1. Organizing for innovation based competition

The remarkable extension of alliances have given rise to a vast theoretical and empirical literature over the last two decades. Data bases have been built and used to test a number of hypotheses on why and how firms cooperate; case studies have been more particularly useful in exploring the operation and results of cooperative agreements. This first part draws on the literature to discuss the hypotheses which are tested in the second part. Two major points are explored. First, the relationships between the objectives of cooperation and the choice of partners, especially for technological partnerships (1.1) This issue is then discussed in the case of international partnerships in order to explore the relationship between the objective of R&D cooperation and the nationality of the partners. The discussion emphasizes the choice between intra-EU versus transatlantic partnerships (1.2)

1.1 Patterns of R&D cooperation

The literature on cooperative agreements spans across disciplines, including economics, strategic management, organization theory and sociology. As a result, a number of research issues, such as the motivations for cooperation or the forms of cooperation have been studied from different perspectives.[2] A large proportion of the literature has focused on the issue of the motivation for cooperation. This first issue has often been related to that of the forms taken by cooperation, while the interactions between the motivation for cooperation and the choice of partners has been less systematically emphasized. It is a quite natural question to raise though, and all the more so that the partnership is important for the firm. From this point of view, Ranjay Gulati (1998) aptly compares the decision to enter into an alliance with that of getting married.

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[2] For reviews discussing and comparing the different theoretical perspectives on cooperation, see (Gulati 1998, Sachwald 1998, Hagedoorn *et al*. 2000).

The discussion below focuses on this issue of the choice of partners, drawing on different strands of literature.

Why and who cooperates in R&D ?

Cooperation as a means to enhance firms' innovative capabilities has attracted a lot of attention. The reasons may be of two distinct types. Firstly, as argued in the introduction, innovation has become a major component of competitive performance, leading firms to strengthen and diversify their technological competences. Second, a number of authors have argued that R&D cooperation may be particularly productive, one major argument being the wide scope for externalities between partners which nevertheless remain free to use results quite independently.[3] This argument should nevertheless be nuanced as R&D cooperation may take various forms and firms also cooperate "close to the market" in order to innovate. R&D cooperation may thus serve different purposes and take different forms, which is important both for empirical studies and policy issues as argued below.

Cooperation and networking have become two prominent features of contemporary R&D management. They may be considered as organizational answers to the current requirements of the process of innovation: frequent introductions of new products and the widening array of technological fields which firms have to know about in order to innovate in a given area. In view of the increasing complexity and multidisciplinarity of research, even the largest firms have to resort to complementary resources from beyond their boundaries (Teece 1992, Gomes-Casseres 1996, Veugelers 1997). In this perspective, research cooperation should logically be the most intense in sectors where R&D is the most intense, in other words in high tech sectors.

Sectoral studies broadly support the idea that R&D is a major area of cooperation, and

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[3] On externalities and the specific characteristics of R&D or technological cooperation, see for example (Jacquemin

more particularly in high tech or emerging industries.[4] Incumbents may use alliances to enter new product areas or technological fields. Such alliances enable the incumbents to expand their knowledge sources with limited investment exposure. They can then test the importance of the new market or technology, as well as evaluate possible strategic solutions – such as standalone entry or the pursuit of an alliance course. This type of behavior has been observed in the medical diagnosis industry for example (Mitchell, Singh 1992). It has also been well documented in the pharmaceutical industry, where incumbent groups have been faced with the biotechnology revolution. From the 1980s on, pharmaceutical groups have extensively resorted to cooperative alliances to progressively expand their knowledge base in the relevant biotechnology fields.[5] Conversely, entry by new biotechtechnology firms is eased by vertical alliances with pharmaceutical, chemical or marketing firms which possess complementary assets (Shan, Walker and Kogut 1994; Calabrese, Baum and Silverman 2000). In other emerging fields, where speed to market and innovative product combinations constitute major competitive strengths, firms knit networks of complementary assets. This is the case for example in the emerging multimedia industry where firms have to combine capabilities from a diversity of established sectors, such as consumer electronics, data processing, telecommunication and publishing (Gomes-Casseres 1996 ; Quélin 1996). The strategic need for high R&D efforts may also play a role within sectors. Among a sample of new American semiconductor firms, the most innovative ones and those faced with the fastest pace of technological change exhibit a higher propensity to cooperate on product development (Eisenhardt and Shoonhoven 1996).

The empirical analysis below further explores the relationship between high R&D intensity

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et al. 1986, Mytelka 1991, Narula 1999).

[4] According to the MERIT-CATI data base, the share of high tech sectors in the total number of R&D cooperations has been increasing from 40% in the 1970s to more than 80% in the late 1990s (Hagedoorn *et al.* 2000)..

and R&D cooperation. It is based on a representative sample of innovative firms located in France, thus eliminating the possibility of a selection bias in favor of high tech cooperations. It uses two levels of aggregation in order to identify the specific behavior of different high tech sectors.

With whom cooperate ?

As argued above, this second question is closely related to that of the motivation for cooperation. In particular, to the extend that firms cooperate in order to pool their innovative resources or to access necessary R&D resources, they should look for partners with adequate research capabilities. Two major frameworks of analysis are particularly useful to consider this issue; the resource based view of the firm and industrial organization models focus on different issues and yield complementary hypotheses. A third approach, the social network perspective, is mentioned after the main hypotheses have been established below.

The resource based perspective considers that the necessity for complementary resources is a key driver of interorganizational cooperation.[6] As a consequence, it suggests that the adequate partners should possess certain specific resources the firm is looking for. Mowery *et al*. (1998) has explored this hypothesis using patent citations indicators to evaluate the technological overlap between partners. This empirical analysis supports the existence of an inverted-U relationship between the degree of technological overlap between two firms and the likelihood of their forming an alliance. This result corresponds to the predictions from the resource based analysis: firms are looking for complementary resources, which means that their technological capabilities should not completely overlap, but that they are sufficiently similar so that the

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[5] See for example, Powell and Brantley (1992), Sharp *et al*. (1994)

[6] This perspective is widely adopted, explicitly or implicitly, by the management literature (Roberts and Berry 1985, Kogut 1991,Gomes-Casseres 1996, Eisenhardt and Schoonhoven 1996, Doz and Hamel 1998).

partners can fruitfully exchange ideas, or at least that one can absorb knowledge from the other.[7] These results do not however support the argument that the role of technological overlap would be stronger in the case of R&D cooperation.[8]

The industrial organization literature has developed a framework of analysis which deals both with the incentives and the risks of technology transfers and R&D cooperation. Industrial organization models focus on the interactions between spillovers and the appropriability issue to predict the occurrence of R&D cooperation. In so doing they draw attention to the risks involved in cooperation, related to involuntary “outgoing spillovers” (Cassiman and Veugelers 1998) to partners.[9] Such considerations suggest that cooperation between competitors are particularly risky and should be limited to two types of cases. Firstly when a strong common interest is identified and secondly when the cooperation concerns far-from-market research leading to generic results. This perspective also suggests that cooperation between private firms will be easier when they are able to prevent or control such outgoing spillovers through legal or strategic protection. Such a protection is much less necessary with public partners because they do not seek commercial applications and because they tend to focus on the most generic or basic end of the R&D complex. Consortia involving a large number of firms, including rivals, tend to focus on this type of research and have often been supported by public funds (Sachwald 1990; Sakakibara 1997; Branscomb and Keller 2000).

Taking both theoretical insights into account suggests that there is a tension between the resource considerations which may constitute an incentive to cooperate and the risks involved.

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[7] The importance of and adequate absorption capacity for learning and technology transfer is widely recognised; it is based on prior in-house R&D efforts (Cohen and Levinthal 1990).
[8] The authors suggest that more detailed data would be necessary to examine this issue thoroughly.
[9] The transaction cost approach also draws attention to risks related to opportunistic behavior. It focuses on the determinants of the degree of internalization firms choose (Hennart 1988, 1991, Sachwald 1990).

This tension is stronger in the case of cooperation with rivals since risks are much lower with suppliers and clients. Vertical cooperation actually belongs to the innovation process, and its importance has probably been growing as firms focus on more a smaller subset of the value-chain in a number of industries.[10] These considerations suggest that the propensity to cooperate for innovation should be higher than the propensity to cooperate with rivals. This hypothesis is tested below. Here again, it is important to be able to use a representative sample of firms, while data bases on cooperative agreements have sometimes suggested that cooperation between rivals was a quite frequent. A complementary hypothesis is that the propensity to cooperate between rivals should be higher in high tech sectors, where firms may feel stronger incentives to pool R&D resources and/or integrate networks in order to establish standards for example.

The social network perspective suggests that firms tend to identify and choose partners among a restricted set of potential partners. They first turn to firms with which they already have some type of relationships, in particular to assess the reliability of the partners (Gulati 1998). This perspective is complementary to those discussed above. It tends to reinforce the constrast between cooperation with client or suppliers on the one hand and rivals on the other hand. As in the case of spillover risks however, cooperation with rivals may nevertheless take place when strategic considerations are sufficiently compelling to prevail. In such cases, cooperation with relatively distant partners may seem attractive, including foreign ones, as argued below.

1.2 Reaching out to foreign systems of innovation

Cooperation may be motivated by the need to pool resources in order to implement potential economies of scale. This may be the case for some R&D cooperation, when the objective is to pool financial resources in order to work on some generic issue. In the case of

[10] Bresnahan (2000) emphasizes this feature in the case of the computer industry by forging the notion of « co-

R&D however, the resource-based approach emphasizes the role of cooperative agreements in matching firms' internal capabilities with complementary capabilities. As a consequence, firms tend to choose their partners according to the extend of the complementarity as argued above. This means that firms will often look for R&D partners who have developed specific and complementary technological resources. Insights from the evolutionary perspective on path dependency and the interactions between firms' capabilities and national systems of innovation, further suggest that such complementarities might be more easily found with foreign partners. Indeed, the specific characteristics of foreign countries, both in terms of natural resources and institutions, generate variegated specialization and innovation patterns. In this perspective, complementarities may be greater between firms originating from very different national contexts. In particular, they may be greater between European, American and Japanese firms than among European firms.

The proportion of intra-EU technological agreements has increased at the end of the 1980s during the runup to the Single Market, but decreased during the 1990s (Narula 1999). The differences in national systems of innovation and specific firms' technological trajectories go a long way in explaining the choice of extra-EU partners by European firms in their catching-up strategies since the late 1980s. European pharmaceutical groups have teamed with American partners in biotechnology (Sharp 1994), while European firms entered various types of cooperation with both American and Japanese partners in information technologies (Hobday 1994, Mouline 1999). By the end of the 90s, transatlantic acquisitions of young high tech companies had also become a popular way to bridge technological gaps (Dalton and Serapio 1999, Sachwald 2000). Foreign acquisitions tend to be more costly than cooperative agreements

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invention » involving buyers and sellers.

however, especially when the objective is uniquely to source technology. Moreover, the acquisition of high tech companies abroad by large groups pose specific management problems related to corporate cultures, so that the alliance solution may remain attractive to reach out to foreign innovation systems.[11]

Resource based and evolutionary perspectives thus suggest that R&D cooperative agreements between firms should be particularly frequent between partners with different capabilities. Two other types of considerations may offset strategic factors however. Firstly, cooperation with foreign companies tend to be more costly and risky than cooperation with closer partners – domestic or European in the case of EU firms. Secondly, public funding may influence the choice of partners. Since the late 1980s, cooperative R&D has been promoted as part of innovation policies on the basis of knowledge spillovers and economies of scale in some research work (Branscomb and Keller 2000; Hagedoorn *et al*. 2000). The EU innovation policy relies mainly on the promotion of cooperative R&D among European firms, which may constitute a strong incentive to choose European partners. Relationships with local universities or public research likewise constitute a strong incentive to strike local cooperations.[12] Besides, as mentioned above, public funding and research projects on generic subjects may greatly alleviate the risks involved in cooperating with close competitors. As a consequence, R&D cooperation aimed at pooling similar resources between firms from a same country or zone are much more likely for generic and public funded research. The cooperation between French carmakers to work on advanced research related to motor technologies is a case in point.

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[11] Different types of contributions and arguments lead to such a conclusion (Roberts and Berry 1985, Kay 1991 Chaudhuri and Tabrizi, 1999, Miotti and Sachwald 2000). Cooperative agreements are themselves difficult to manage and may fail (Kogut 1988; Garrette and Dussauge 1995), but they tend to be more focused and less costly.
[12] In this case a firm would cooperate with public institutions, but in a number of European projects, firms participate in large research programs involving both public and private participants.

These different considerations suggest that international R&D cooperation should be strongest in the cases where the comparative technological advantage of the countries from which the partners originate are different and complementary.[13] The hypothesis of a positive influence of comparative advantage on the propensity to cooperate has been examined by some empirical studies. Shan and Hamilton (1991) found that Japanese firms were more likely to form technological cooperations with American firms than with local partners. They interpreted this result as supporting their hypothesis that comparative advantage embedded in firms of a certain nationality is an important motivating factor to enter cooperation. Similarly, Veugelers (1995) has found that European firms tend to cooperate with extra-European partners in sectors in which they have a competitive disadvantage. Conversely, European firms tend to enter intra-European partnerships in sectors in which they are relatively more competitive like telecommunications and aerospace (Mouline 1999, Sachwald 2000).

The section below further explores the hypothesis of transatlantic technology sourcing through R&D cooperation in the case of French firms.

2. Testing for the types of partners

Previous studies and the descriptive statistics above suggest to include quite a number of factors as determinants of the probability to cooperate in R&D. They further suggest that the propensity to cooperate with certain types of partners depends on the precise objectives of cooperation. The empirical tests specifically addresses this issue by distinguishing among vertical and horizontal cooperations, between public and private partners as well as between domestic, European and extra-European partners.

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[13] As in the case of technological overlap discussed above (Mowery *et al.* 1998) the gap should not be too wide though.

2.1. The scope of R&D cooperation of firms located in France

Cooperation has been widely studied since the 1980s but results are difficult to compare as the data bases on inter-firm agreements tend to be designed in various ways. The vast majority of authors agree on the growing importance of the phenomenon. A number of studies also emphasize the intensity of cooperation in high tech sectors, but such a conclusion may be biased by the focus on technological cooperation.[14] Indeed, in mid-tech or low-tech sectors cooperation may be quite lively but focus rather on supply partnering or commercial issues.[15] A number of studies have focused on alliances between rival firms. Firstly because some empirical studies have estimated that a majority of alliances are horizontal[16] and secondly because cooperation between rivals was considered as a most interesting phenomenon to study in a competitive context (Bresnahan and Salop 1986, Garrette and Dussauge 1995). Other data on technological alliances and sectoral studies suggest however that vertical cooperation with suppliers and cooperation with partners from other sectors are more frequent (EU 1997). Here again, the focus on technological cooperation may explain the divergence, with rivals being more prone to cooperate to reap economies of scale or to internationalize than to conduct joint R&D.[17]

The French survey which is used here has been conducted as part of the second European survey on innovation (CIS2). Firms have been asked a number of questions on their R&D practices in 1994-96, including on cooperation for innovation. The data is thus quite different from that of bases which record cooperative agreements.[18] In France, the survey was sent to more

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[14] The MERIT-CATI and the IFR/SDC data bases in particular.
[15] According to INSEAD data base on « strategic alliances », one-third concern technology, 43% production and 25% marketing (EU 1997).
[16] According to Marity and Smiley (1983) most alliances are between rivals. According to the data base of 668 alliances recorded between 1986 and 1992 and used by Veugelers (1995), 55% are between horizontal partners (3 digit level Nace classification).
[17] See also the argument above about economies of scale in R&D.
[18] This type of survey has been used by some previous empirical work on cooperation (Kleinknecht and Reijnen

than 5,000 firms, which represent more than 20,000 firms from the manufacturing sectors. All firms with more than 500 employees are included. The empirical analysis conducted here includes 2378 innovating fims (non innovative firms do not answer questions about cooperation).

According to table 1, a third of the firms choose to cooperate in R&D. This is substantial but also means that only a minority of firms enter R&D cooperations.[19] The proportion is substantially higher for firms from high tech sectors (53%), which constitutes a confirmation of the above argument, i.e that these firms use cooperation to cope with the specific requirements they face in order to innovate.[20] The propensity to cooperate in R&D is particularly high for the largest firms (67%); their propensity to cooperate is much higher with all types of partners, but less so for clients. It is also more marked for foreign partners than for French partners, which is logical since large companies tend to have a more international reach.

Table 1. The rate of R&D cooperation among innovating firms by type of partners, in %

				Firms' characteristics			
Partners	All firms[1]	Groups	Foreign groups	> 500 (et prod nouveau?)	In high tech sector[2]	Patent in 1994-96	New product in 1994-96
All types of partners	33.6	49.0	46.9	66.8	52.7	47.4	40.2
Within the group	16.9	33.6	35.9	50.1	31.6	24.8	21.8
Clients	15.0	20.9	18.7	27.9	23.5	21.8	20.9
Suppliers of components	11.6	17.3	15.1	33.5	22.2	18.9	16.8
Suppliers of equipment	8.8	13.2	10.2	28.9	16.6	14.6	11.9
Competitors	4.3	7.3	3.0	15.4	12.8	7.1	5.5
Universities or organizations	13.3	19.8	15.9	37.6	22.1	25.8	16.2

1992, Veugelers 1997, Cassiman and Veugelers 1998).

[19] Kleinknecht and Reijnen (1992) reported somewhat lower proportion for firms in the Netherlands (22% of firms conducting R&D report cooperation in R&D with domestic firms and 13% with foreign firms).

[20] Kleinknecht and Reijnen (1992) reported a different result, but they used a broad sectoral classification to distinguish sectors and did not really isolate high tech industries (their table 3 includes such aggregates as chemicals and plastics and does not isolate electronics for example).

French	28.0	40.2	32.7	59.1	45.9	40.6	33.4
European	14.9	25.7	30.6	46.4	30.3	24.6	20.3
American	6.7	12.7	16.0	30.3	19.2	13.9	10.2
Japanese	2.2	4.1	5.0	12.8	6.4	5.1	3.5
Others	3.1	5.8	5.2	9.7	8.7	5.0	4.6

1. Innovative firms of the survey with more than 10 employees.
2. OECD classification

Groups tend to cooperate more than other firms, but their major partner is themselves. This means that groups consider that cooperation within the group, between subsidiaries, does indeed constitute cooperation. From the point of view of inter-firm cooperation however, intra-group cooperation has to be considered as a specific case. Competitive risks in particular are *a priori* lower. The specific contribution of intra-group R&D cooperation may also be lower. The importance of intra-group cooperation suggests that a group variable should be included to test the determinants of R&D cooperation.

The propensity to cooperate with competitors is particularly low, which confirms previous results mentioned above: firms tend to avoid R&D cooperation with rivals. Conversely, table 1 confirms the more important role played by clients and suppliers in the innovative process. Cooperation with academic organizations is markedly more intense for the largest firms and for patenting firms, which seems to correspond to the specific needs these firms have in terms of basic or frontier R&D capabilities. Conversely, firms introducing new products do not cooperate very intensely, which suggest that product innovation is less demanding in terms of R&D *per se*.

Large firms and firms in high tech sectors are more inclined to choose foreign partners. The choice of European partners appears specific though. European partners seem relatively more attractive to foreign groups than to the largest firms, which exhibit a particularly strong propensity to cooperate with American and Japanese partners. One possible explanation is related to the fact that foreign groups, European, American and Japanese equally, tend to cooperate mostly with their parent company.[21] Since the foreign groups located in France are mostly European, their French subsidiaries tend to cooperate with firms located in Europe. A second explanation is related to another feature of international R&D, namely the fact that the largest firms are strongly attracted towards American and Japanese partners. One hypothesis would be that American and Japanese cooperations are particularly attractive, but that only the largest firms can strike such international ventures.

2.2 Types of cooperation and independent variables

Four types of partners

Theoretical considerations and previous empirical results suggest to distinguish four types of partners: public research institutions, private vertical partners, private horizontal partners or rivals, and intra-group partners. The influence of group affiliation is captured by an independent variable and we consider four different dependent variables: first, the probability to cooperate in order to innovate, second, to cooperate with public institutes or academic institutions, third, to cooperate vertically with suppliers or customers and fourth, to cooperate with rivals. Due to the binary nature of the dependent variables, the statistical estimation uses a logit specification. The regression coefficients estimate the impact of the independent variables on the probability that the firm will conduct cooperative R&D.

Four sets of independent variables are included as determinants of the propensity to cooperate in R&D; they relate to sectoral characteristics, firms' characteristics, obstacles to innovation and public funding. Variables are listed in table 2.

Sectoral variables

Sectoral characteristics are captured with two methods, firstly, two different typologies,

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[21] In a number of cases, their cooperations are uniquely with the country of origin.

secondly an indicator of comparative advantage .

The first typology combines a broad sectoral classification with R&D intensity categories. It relies on the French industrial classification which divides manufacturing into 13 categories (food and minerals being excluded from the sample). R&D intensity is characterized with the OECD classification which ranks industries in four categories, low tech (LT), Mid-low and mid-high tech (MLT, MHT), high tech (HT). Based on the above discussion, firms in high tech and possibly mid-high tech sectors should exhibit a relatively high propensity to cooperate in R&D.

The second typology provides a more detailed approach of high tech sectors. It is also based on the French industrial classification but uses a finer aggregation level and only includes high tech and mid-high tech categories (18 categories).

In the case of cooperation with American partners, an indicator of trade specialization is used to test the positive influence of US comparative advantage.

Firms' characteristics

Various studies indicate that large firms participate in numerous R&D cooperative projects. Smaller innovative firms may however enter a number of technological alliances, so that absolute size may not increase the probability to cooperate – the argument could even be that large firms need cooperation less as they have accumulated in-house R&D in numerous fields.

In their empirical study of the behavior of Dutch firms,[22] Kleinknecht and Reijnen (1992) found no influence of firm's size on the propensity to cooperate in R&D. According to that study, size increased the probability to cooperate with research institutes, but not with private firms. This rather surprising result may be due to the fact that the estimate of the probability to cooperate included other independent variables positively related to size, in particular the

[22] This study was based on a survey similar to the one used here, see the box on the presentation of the data.

propensity to export and the existence of an R&D laboratory in the firm. Veugelers (1997) goes deeper into this issue by exploring the interactions between internally financed R&D expenditures and cooperation with a simultaneous two-equation model. She finds that firms who spend more on R&D have a significantly higher probability of cooperating, but that smaller innovative firms are more likely to cooperate than larger ones. In other words, the most relevant variable is not the size of the firm (as measured by sales) but the size of R&D spending, or more broadly, the research orientation of firms.

Empirical analyses of R&D cooperation confirm theoretical predictions about the crucial role of absorption capacity in inducing firms to cooperate. The existence of a permanent R&D structure within the firm positively influences its propensity to cooperate (Kleinknecht and Reijnen1992, Veugelers 1997).

Taking these different results into consideration, but having no data on the amount of R&D spending, we include both the size of firms and an indicator of their absorption capacity in the independent variables (table 2).

Descriptive statistics in part 2 underscore the extend of intra-group R&D cooperation. As a consequence, we incorporate GROUP, a dummy variable which is equal to 1 when the firm belongs to a group.

Obstacles to innovation

R&D cooperation is motivated by the need to draw on complementary resources, but also to reduce risks and overcome a number of specific obstacles to innovation. Cooperative behavior may thus be positively related to a number of obstacles to innovation. Based on the questionnaire, we identify five types of obstacles with dummies: market information obstacles, technological obstacles, cost obstacles, obstacles due to legislation or standards, and high risks. These obstacles should increase the propensity to cooperate, except for those related to legislation and other rules because it is not possible to know exactly what firms may have referred to when they have answered. The need to agree on a standard does generate cooperation, but other rules may have a different impact (table 2).

Public funding

Public funding tends to have a positive influence on firms' R&D spending. Veugelers (1997) considers that public funding thus has an indirect influence on the propensity to cooperate in R&D through this channel. The European innovation policy as well as national schemes sponsor cooperative R&D projects, which may constitute a specific incentive to cooperate. The survey questionnaire does not allow to distinguish this specific source of R&D funding. As a consequence, equations include a dummy variable which is equal to 1 when the firm benefits from R&D subsidies.

Table 2. Summary of independent variables and expected influence on the probability to cooperate

Variable name	Description	Expected sign
Size dummies	1 if the firm belongs to the specified size category	+ for larger sizes
Sectoral dummies	1 if the firm belongs to the sector	+ in case of comparative advantage of the country of origin of the partner
HT	High tech sector	+
MHT	Middle-high tech sector	+
MLT	Middle-low tech sector	?
LT	Low-tech sector	-
CAUS	Contribution to trade balance indicator[1] , USA	+
Group	1 if the firm belongs to a group	+
Permanent R&D	1 if the firm conducts R&D permanently	+
Cost obstacles	High cost constitutes an obstacle to innovation	+
Market information	Lack of market information constitutes an obstacle to innovation	+
Technological information	Lack of technological information constitutes an obstacle to innovation	+
High risks	High risks constitute an obstacle to innovation	+
Rules	Legislation or standards constitute obstacles to innovation	?

1. $$\mathrm{CTBi} = \frac{100}{(X+M)/2}\left[(Xi - Mi) - (X - M)\frac{(Xi+Mi)}{(X+M)}\right]$$

2.3 Results

Table 3 shows the results of the estimates with the first typology of sectors and table 3 with the more detailed classification, focusing on high tech and middle high tech sectors. These two tables show that the determinants of cooperation are influenced by the type of partners, or, more exactly that the partners are chosen in view of specific objectives.

These tests confirm that large firms tend to cooperate more, and more markedly for cooperation with rivals and with public institutions. Firms which conduct R&D permanently and receive R&D subsidies also tend to cooperate more. Taken together, these results suggest that the propensity to enter technological cooperation is related to the propensity to conduct R&D – which is itself positively related to public funding for research.[23] These factors do not equally influence all types of cooperation though. Size has a very strong impact on cooperation with rivals and with academic institutions, while vertical cooperation is relatively more influenced by sectoral characteristics and obstacles to innovation perceived by firms. According to table 1, cooperation with rivals is particularly strong in high tech sectors. Table 3 indicates that cooperation with rivals, which is the less likely situation, is particularly strong in sectors with very high R&D intensity such as aerospace, telecommunication equipment, instruments, electronic components and pharmaceuticals. It is also strong in the automobile sector and fine chemicals.

Vertical technological cooperation is not particularly concentrated in high tech, as is the case of cooperation between rivals. Cooperation with public institutions is also not concentrated in high tech sectors. Table 3 shows that vertical cooperation is relatively frequent in the automobile sector, in mineral products and in electronics. According to table 4 which focuses on a limited number of smaller sectors, it is particularly marked for cars, computers and telecommunications. Table 3 indicates that cooperation with public institutions is relatively more intense for pharmaceuticals/cosmetics/cleaning products, mechanical and mineral products. Table 4 further shows that it is more intense in pharmaceuticals, instruments and organic chemicals.

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[23] For a discussion and estimates focusing on these interactions, see Veugelers (1997).

Table 3. Probability to cooperate for innovation (*Prob*)

Variable name	Cooperation	With Public Institutions	Vertical	With Rivals
Constant	-2.901 *(0.000)*	-5,607 *(0.000)*	-3.116 *(0.000)*	-6.112 *(0.000)*
S1019	-0.878 *(0.411)*	1.096 *(0.319)*	0,685 *(0.518)*	-28.26 *(1.000)*
S2049	0.214 *(0.183)*	0.199 *(0.424)*	0,073 *(0,682)*	0.361 *(0.389)*
S100199	0.194 *(0.277)*	0.408 *(0.107)*	0.164 *(0.397)*	0.082 *(0.854)*
S200499	0.676 *(0.000)*	0.842 *(0.000)*	0.632 *(0.000)*	0.914 *(0.013)*
S500	0.941 *(0.000)*	1.307 *(0.000)*	0.977 *(0.000)*	1.218 *(0.000)*
Edition	0.411 *(0.291)*	-0.612 *(0.398)*	0.524 *(0.221)*	0.061 *(0.949)*
Pharmaceuticals Cosmetics	0.547 *(0.220)*	1.223 *(0.043)*	0.379 *(0.430)*	0.415 *(0.651)*
Household Equipment	0.116 *(0.754)*	0.473 *(0.383)*	0.277 *(0.496)*	0.282 *(0.737)*
Automobile	0.737 *(0.084)*	0.525 *(0.378)*	1.026 (*0.024)*	0.944 *(0.285)*
Transportation Equipment	0.445 *(0.367)*	0.556 *(0.387)*	0.640 *(0.210)*	0.832 *(0.371*)
Mechanical Equipment	0.687 *(0.070)*	1.095 *(0.045)*	0.589 *(0.156)*	0.416 *(0.628)*
Electric & Electronic Eq.	0.469 *(0.267)*	0.775 *(0.185)*	0.974 *(0.032*)	0.802 *(0.366)*
Mineral products	0.811 *(0.039)*	1.387 *(0.012)*	0.723 *(0.091)*	0.626 *(0.475)*
Textile	-0.023 *(0.949)*	-0.044 *(0.937)*	-0.203 *(0.617)*	-1.669 *(0.182)*
Pulp, paper	0.013 *(0.970)*	-0.451 *(0.427)*	0.166 *(0.674)*	-0.233 *(0.788)*
Chemicals, plastic	0.678 *(0.080)*	0.849 *(0.127)*	0.694 *(0.100)*	0.503 *(0.560)*
Metal works	0.406 *(0.229)*	0.697 *(0.162)*	0.267 *(0.474)*	0.796 *(0.305)*
Electronics	0.560 *(0.163)*	0.479 (0.421)	0.913 *(0.047)*	0.727 *(0.415)*
High Tech	0.676 *(0.004)*	0.444 *(0.104)*	0.184 *(0.444)*	0.834 *(0.019)*
Middle High Tech	0.248 *(0.117)*	0.466 *(0.012)*	-0,202 *(0.214)*	0.303 *(0.273)*
Low Tech	0.112 *(0.582)*	0.460 *(0.081)*	0.046 *(0.833)*	0.455 *(0.220)*
Public Funding	0.982 *(0.000)*	1.656 *(0.000)*	0.930 *(0.000)*	1.150 *(0.000)*
Group	1.030 *(0.000)*	1.417 *(0.000)*	0.506 *(0.000)*	0.992 *(0.004)*
Permanent R&D	0.547 *(0.000)*	0.565 *(0.003)*	0.518 *(0.000)*	0.381 *(0.190)*
Cost Obstacles	0.227 *(0.031)*	0.134 *(0.312)*	0.219 *(0.046)*	0.464 *(0.018)*
Market Information	0.110 *(0.302)*	0.451 *(0.000)*	0.323 *(0.002)*	0.042 *(0.818)*
High Risks	0.091 *(0.391)*	0.131 *(0.312)*	0.274 *(0.011)*	0.171 *(0.352)*
Technological Information	0.278 *(0.018)*	0.119 *(0.388)*	0.245 *(0.038)*	0.062 *(0.748)*
Rules	-0.435 *(0.001)*	0.053 *(0.742)*	-0.341 *(0.015)*	0.419 *(0.052)*
Log Likelihood	-1348.2	-925.7	-1275.0	-525.1
Probability (LR stat)	(0.000)	(0.000)	(0.000)	(0,000)

Table 4. Determinants of R&D cooperation, by type of partner (*Prob*)

Variable name	Cooperation	With Public Institutions	Vertical	With Rivals
Constant	-2.454 *(0.000)*	-4.588 *(0.000)*	-2.741 *(0.000)*	-5.543 *(0.000)*
S1019	-0.920 *(0.383)*	0.547 *(0.611)*	-0,688 *(0.513)*	-31.40 *(1.000)*
S2049	0.206 *(0.198)*	-0.013 *(0.950)*	-0.063 *(0.724)*	0.307 *(0.463)*
T100199	0.161 *(0.364)*		0.158 *(0.414)*	0.120 *(0.789)*
T200499	0.605 *(0.000)*	0.563 *(0.002)*	0.588 *(0.000)*	0.946 *(0.011)*
TP500	0.888 *(0.000)*	1.055 *(0.000)*	0.965 *(0.000)*	1.271 *(0.000)*
Pharmaceuticals	0.817 *(0.002)*	0.852 *(0.002)*	-0.300 *(0.284)*	0.904 *(0.012)*
Games, Sport items	-0.005 *(0.989)*	-0.290 *(0.622)*	0.204 *(0.607)*	0.280 *(0.712)*
Audio, Video	0.129 *(0.823)*	0.425 *(0.528)*	0.375 *(0.520)*	-0.112 *(0.917)*
Optics Photo	0.644 *(0.262)*	0.502 *(0.456)*	-0.181 (*0.774)*	0.215 *(0.844*)
Cars	0.531 *(0.149)*	0.028 *(0.949)*	0.663 *(0.067)*	1.114 *(0.016)*
Car components	0.219 *(0.442)*	-0.342 *(0.319)*	0.418 *(0.138)*	0.103 *(0.825)*
Aerospace	0.665 *(0.208)*	-0.059 *(0.904)*	0.784 *(0.103*)	1.432 *(0.004)*
Machine tools	0.315 *(0.486)*	0.219 *(0.698)*	0.293 *(0.532)*	0.021 *(0.984)*
Weapons, munitions	0.134 *(0.886)*	1.091 *(0.259)*	0.559 *(0.539)*	-32.27 *(1.000)*
Computers	1.114 *(0.035)*	0.199 *(0.744)*	1.223 *(0.014)*	-0.372 *(0.726)*
Telecom	0.685 *(0.082)*	-0.142 *(0.753)*	1.010 *(0.007)*	1.256 *(0.006)*
Medical Eq.	0.168 *(0.686)*	0.526 *(0.256)*	-0.149 *(0.738)*	0.707 *(0.282)*
Instruments	0.244 *(0.354)*	0.528 *(0.067)*	0.298 *(0.257)*	1.134 *(0.001)*
Ceramics, Building Mat.	0.243 *(0.332)*	0.333 *(0.269)*	0.348 *(0.175)*	0.022 *(0.967)*
Organic Chemicals	0.893 *(0.017)*	1.043 *(0.004)*	0.244 *(0.479)*	-0.534 *(0.480)*
Fine Chemicals	0.174 *(0.516)*	0.096 *(0.767)*	-0.277 *(0.344)*	0.944 *(0.014)*
Electrical Equipment	0.485 *(0.028)*	-0.023 *(0.931)*	0.310 *(0.161)*	0.527 *(0.111)*
Electronic composants	0.412 *(0.253)*	0.149 *(0.705)*	0.552 *(0.115)*	1.008 *(0.026)*
Public Funding	0.999 *(0.000)*	1.634 *(0.000)*	0.937 *(0.000)*	1.137 *(0.000)*
Group	1.098 *(0.000)*	0.679 *(0.000)*	0.564 *(0.000)*	0.958 *(0.005)*
Permanent R&D	0.581 *(0.000)*	1.482 *(0.000)*	0.554 *(0.000)*	0.360 *(0.214)*
Cost Obstacles	0.237 *(0.024)*	0.130 *(0.326)*	0.224 *(0.041)*	0.395 *(0.046)*
Market Information	0.122 *(0.253)*	0.433 *(0.000)*	0.316 (*0.003)*	0.083 *(0.654)*
High Risks	0.064 *(0.543)*	0.123 *(0.338)*	0.246 *(0.022)*	0.213 *(0.248))*
Technological information	0.276 *(0.019)*	0.110 *(0.423)*	0.249 *(0.036)*	0.051 *(0.795)*
Rules	-0.414 *(0.002)*	0.060*(0.710)*	-0.285 *(0.043)*	0.346 *(0.114*
Log Likelihood	-1355.2	-1220.3	-1274.0	-522.1
Probability (LR stat)	(0,000)	(0.000)	(0.000)	(0.000)

Variables on the obstacles to innovation complement the sectoral perspective. Table 3 and 4 give the same results from this point of view, confirming that cooperation with different partners answer different problems. Cooperation with rivals is stimulated by high costs and problems with rules or norms. This suggests that cooperation with rivals aims at increasing the scale of R&D and creating network or club effects in high tech sectors. This sort of effect is not sought after by firms cooperating vertically ("Rules" is significantly negative). Vertical cooperation is stimulated by all the other types of obstacles to innovation though. Cooperation with public institutions is a practice of firms which consider that their innovative projects have been hindered by lack of market information. This may be interpreted as meaning that these firms are investing heavily on R&D, including quite generic research with public institutions, but have more difficulties with marketing. A related explanation would be that these firms work at quite radical types of innovation, for which markets are uncertain or underdeveloped.

3. Testing for the nationality of partners

The determinants of cooperation also differ according to the nationality of the partners. Table 5 distinguishes the cases where partners are French (col. 1) from those where they are European or American. In the latter cases, the table further distinguishes the case of French firms – thus eliminating foreign subsidiaries located in France. This distinction is important because subsidiaries from foreign groups which are located in France tend to cooperate with their parent company. The two columns isolating French firms thus aim at identifying their specific motivations for cooperating with European or American partners.

Table 5. Determinants of the propensity to cooperate with French, European and American partners (*Prob*)

Variable name	French partners	European partners to		American partners to	
	1	2: All types of firms	3: French firms	4: All types of firms	5: French firms
Constant	-2.774 *(0.000)*	-4.188 *(0.000)*	-4.425 *(0.000)*	-5.200 *(0.000)*	-5.872 *(0.000)*
Size 10 to19	-0.664 *(0.529)*	0.352 *(0.745)*	0,858 *(0.426)*	-29.90 *(1.000)*	-30.152 *(1.000)*
Size 20 to 49	0.129 *(0.448)*	0.074 *(0.749)*	0.074 *(0.792)*	-0.892 *(0.032)*	-0.978 *(0.083)*
Size 100 to 199	0.199 *(0.285)*	-0.089 *(0.714)*	0.135 *(0.649)*	0.193 *(0.546)*	0.598 *(0.154)*
Size 200 to 499	0.539 *(0.001)*	0.777 *(0.000)*	0.799 *(0.002)*	0.674 *(0.014)*	0.899 *(0.024)*
Size above 500	0.871 *(0.000)*	1.107 *(0.000)*	1.281 *(0.000)*	1.283 *(0.000)*	1.620 *(0.000)*
Pharmaceuticals	0.710 *(0.006)*	0.903 *(0.000)*	0.768 *(0.041)*	1.294 *(0.000)*	0.949 *(0.036)*
Games, Sport items	0.358 *(0.350)*	0.024 *(0.958)*	-0.076 *(0.899)*	-0.101 *(0.875)*	-0.626 *(0.560)*
Audio, Video	-0.262 *(0.667)*	-0.932 *(0.253)*	-1.057 *(0.347)*	1.663 *(0.009)*	1.971 *(0.019)*
Optics, Photo	0.264 *(0.654)*	-0.088 *(0.904)*	0.864 (*0.265)*	-0.374 *(0.729*)	0.450 *(0.696)*
Cars	0.561 *(0.127)*	0.535 *(0.176)*	0.682 *(0.129)*	-0.046 *(0.931)*	-0.233 *(0.731)*
Car components	0.187 *(0.509)*	0.716 *(0.012)*	0.319 *(0.561)*	1.125 *(0.000)*	0.889 *(0.168)*
Aerospace	0.942 *(0.074)*	0.086 *(0.856)*	0.514 *(0.350*)	0.812 *(0.093)*	1.105 *(0.052)*
Machine tools	-0.030 *(0.949)*	-0.145 *(0.808)*	-0.602 *(0.456)*	0.533 *(0.426)*	-0.343 *(0.752)*
Weapons, munitions	0.279 *(0.765)*	1.428 *(0.135)*	1.477 *(0.122)*	1.677 *(0.170)*	1.937 *(0.126)*
Computers	0.444 *(0.376)*	1.044 *(0.047)*	1.946 *(0.009)*	2.261 *(0.000)*	2.527 *(0.001)*
Telecommunications	0.848 *(0.029)*	0.937 *(0.016)*	0.932 *(0.043)*	1.243 *(0.002)*	1.724 *(0.000)*
Medical Equipment	0.071 *(0.867)*	-0.003 *(0.994)*	0.194 *(0.811)*	1.556 *(0.001)*	2.680 *(0.000)*
Instruments	0.206 *(0.436)*	0.210 (*0.462)*	0.177 *(0.628)*	0.878 *(0.007)*	1.135 *(0.006)*
Ceramics, Building Material	0.194 *(0.448)*	0.408 *(0.153)*	0.152 *(0.694)*	-0.471 *(0.334)*	-0.427*(0.572)*
Organic Chemicals	0.590 *(0.091)*	0.927 *(0.008)*	1.530 (*0.001)*	1.524 *(0.000)*	1.896 *(0.000)*
Fine Chemicals	-0.298 *(0.291)*	0.365 *(0.214)*	0.587 *(0.133)*	0.946 *(0.003)*	1.008 *(0.031)*
Electrical Equipment	0.298 *(0.179)*	0.377 *(0.112)*	0.380 *(0.226)*	0.538 *(0.002)*	0.641 *(0.088)*
Electronic components	0.387 *(0.280)*	0.505 *(0.182)*	0.493 *(0.285)*	0.598 *(0.163)*	1.110 *(0.036)*
Public Funding	1.210 *(0.000)*	0.844 *(0.000)*	1.032 *(0.000)*	0.538 *(0.046)*	1.037 *(0.000)*
Group	0.895 *(0.000)*	1.390 *(0.000)*	1.118 *(0.000)*	1.452 *(0.000)*	1.169 *(0.001)*
Permanent R&D	0.685 *(0.000)*	0.760 *(0.000)*	0.787 *(0.000)*	0.739 *(0.002)*	0.680 *(0.068)*
Cost Obstacles	0.176 *(0.102)*	0.413 *(0.000)*	0.363 *(0.026)*	0.194 *(0.203)*	0.438 *(0.050)*
Market Information	0.117 *(0.278)*	0.339 *(0.004)*	0.418 (*0.008)*	0.337 *(0.021)*	0.536 *(0.010)*
High Risks	0.231 *(0.030)*	0.097 *(0.410)*	0.207 *(0.190)*	0.135 *(0.360)*	0.035 (0.869)
Technological information	0.334 *(0.004)*	-0.075 *(0.564)*	-0.101 *(0.561)*	0.192 *(0.218)*	0.326 *(0.134)*
Rules	-0.361 *(0.009)*	-0.147 *(0.340)*	-0.038 *(0.854)*	-0.020 *(0.913)*	-0.012 *(0.963)*
Log Likelihood	-1308.2	-1061.8	-630.5	-738.8	-379.3
Probability (LR stat)	0.000	0.000	0.000	0.000	0.000

Size always influences the propensity to cooperate, but more strongly as the partner is more distant. Size has even a stronger effect for cooperation with Japanese partners than for American ones (this estimate is not reproduced here). In some sectors, firms cooperate with all types of partners: pharmaceuticals, emission and telecommunication equipment as well as organic chemicals. The influence of those sectors on the propensity to cooperate increases though as partners are more remote. Cooperation in aerospace is high with French partners or with American partners. This should probably be interpreted by taking into account both the strength of the French and American aerospace industries and of the traditional national champion approach in these industries.[24]

Technological cooperation with European and American partners is relatively strong in automobile components, but mostly for foreign subsidiaries (col. 2 and 4) since the significance of the coefficient disappears when only French firms are considered (col. 3 and 5). Automobile components thus clearly illustrate the privileged relationship between French subsidiaries of foreign companies and their parent which has been discussed above. The same remark applies to electronic components, but only in the case of cooperation with American partners (col. 4 and 5).

French firms tend to enter technological cooperation with European and American partners in different sectors. Four sectors are common : pharmaceuticals, computers, telecommunications and organic chemicals (with a stronger sectoral coefficient in the case of the US though). In a greater number of sectors, French firms tend to favor cooperation with American partners however: aerospace, audio and video equipment, medical equipment, instruments, fine chemicals, electrical equipment and electronic components. In a number of cases, such as medical

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[24] On this perspective for aerospace and defence industries, see Sachwald (1999).

equipment[25] or electronic components, this distribution can be related to the strong competitive advantage of American companies. In some cases, European innovation policies may play a complementary role. The propensity to cooperate with American partners is very strong in computers (col. 5 compared to 3), but European R&D programs have probably stimulated intra-European cooperation. Tests which are not reproduced here on cooperation with Japanese partners tend to reinforce the positive influence of technological and competitive advantage of foreign firms. The propensity of French firms to cooperate with Japanese partners is higher in electronic components and instruments in particular.

The test reported in table 6 measures the influence of comparative advantage on the propensity to cooperate more directly. The indicator of comparative advantage is used along with the technological typology. The test is a weighted logit which gives a more accurate account of the whole population of firms (weights are redressing coefficients). Results confirm that French firms tend to cooperate with American partners in high tech sectors where the US exhibit comparative advantages.

Table 6. Probability for French firms to cooperate for innovation with American partners

Variable name	Coeff.	*Prob.*
Constant	-13.082	*0.000*
Log of size	1.183	*0.000*
CAUS	0.411	*0.003*
HT	1.721	*0.000*
MHT	1.272	*0.000*
MLT	0.558	*0.089*
Public Funding	0.854	*0.000*
Group	1.074	*0.006*
Permanent R&D	0.711	*0.081*
Technological information	0.468	*0.033*
Cost Obstacles	0.478	*0.043*
Market Information	0.462	*0.030*
Rules	-0.179	*0.493*
High Risks	-0.068	*0.756*

[25] For which the coefficient is particularly high (col. 5).

Log Likelihood	-397.567	-
Probability (LR)	0.000	-

Number of observations: 1435

These different results suggest that French firms enter R&D cooperation with foreign partners in order to reach out to their technological capabilities. Estimates not reproduced here further suggest that cooperations with American and Japanese partners are particularly efficient; the propensity to patent or introduce new products[26] is positively influenced by cooperation with firms from Japan or the US – which is not the case for cooperation with European partners.

Conclusions

The pervasiveness of networking has become an important feature in R&D practice. This paper confirms though that since cooperation is costly and risky, firms tend to collaborate in order to innovate with caution. The paper has focused on the choice of partners. Firms tend to cooperate more easily with partners from the same country and with their usual partners in the value chain – suppliers and clients. In sectors where innovation is particularly demanding, as in high tech, firms nevertheless venture into more risky cooperations with rivals. The same type of positive interactions have been identified for the choice of foreign partners: French firms tend to choose foreign partners in cases where the latter have access to strong research assets. In high tech sectors, this is the case in particular of American firms. French firms have thus resorted to R&D cooperation with American partners as a way to reach out to the US innovation system.

This result has to be interpreted in the context of increasing internationalization of R&D.

[26] The survey only informs on whether or not firms patent or introduce new products, and not on the intensity of these activities.

Growing foreign R&D spending and growing shares of foreign patents in multinationals' portfolios can not be explained by the need to adapt product and services to foreign markets. The internationalization of R&D is also pulled by foreign technology sourcing as part of the reorganization of corporate R&D.[27]

International technology sourcing, along with "brain circulation"[28] should be more fully taken into account by innovation policies. This perspective has specific implications for public funding of cooperative R&D. The above results may be more particularly relevant to EU policy, which has been largely based on the promotion of intra-European R&D cooperation.

The framework for EU innovation policy has been elaborated at the beginning of the 1980s, when public authorities sought means to fight eurosclerosis and the Japanese challenge. Intra-European consortia have been devised, based on the experience in information technologies and the ESPRIT program, as ways to close the technology gap and to catch up with American and Japanese competitors. Sectoral studies (Langlois and Steinmueller 1999) as well as more general analyses (Peterson and Sharp 1998) conclude that EU research consortia have only weakly contributed to this objective. These disappointing results are partly due to multiple objectives. Indeed, the European R&D programs also aimed at stimulating cooperation in Europe to create a pan-European community of researchers and also aimed at promoting cohesion among the EU member countries. EU programs and EUREKA did succeed at creating European networks of researchers and greatly stimulated pan-European cooperation.[29] EU programs also provided new opportunities to firms and research institutions of the cohesion countries (Sharp 1998). Catching-up with world best practice and frontier technologies may have been contradictory with these

[27] On this argument, see in particular (Niosi 1999, Sachwald 2000).
[28] As opposed to the traditional perspective summarized by the notion of « brain drain » (Weil 2000).
[29] This has been argued by numerous evaluations and studies on the Framework Programmes and EUREKA projects.

intra-European objectives though. Besides, European subsidies have been relatively modest – as have been those of a number of consortia in the US and Japan.

The experience of Japan and the US suggest a more general explanation for the modest results of research consortia. Indeed, a number of studies of publicly supported research consortia in both countries conclude that they are at best complementary to firms' strategies to catch up, either through their own efforts to innovate or through increased productivity.[30] Because of appropriability issues which have been mentioned above, large publicly funded consortia are best suited to foster research dissemination and stimulate vertical collaboration. This may be quite useful, as in the cases of the Japanese VLSI project or SEMATECH in the United States, but it is not sufficient to catch-up. Besides, national or EU consortia may prove much less useful in the context of global innovation-based competition where public institutions can not hope to nurture national champions anymore. This is why the "ESPRIT model" (Peterson and Sharp 1998) based on the assumption that European former national champions had to be encouraged to cooperate and pool their resources is not relevant anymore.

The propensity of French firms to cooperate with American rather than European partners in a number of high tech sectors, and especially in information technologies, may appear as a paradox since EU policies aimed at encouraging intra-European R&D collaboration. This paper suggests that the way to solve this paradox is to look at firms' objectives and actual determinants of their choice of partners. This perspective may contribute to the debate on the role of publicly funded R&D consortia as a major instrument of EU innovation policy.

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[30] On Japanese consortia, see in particular (Sakakibara 1997) ; on SEMATECH (Mowery *et al.* 1998; Langlois and Steinmueller 1999) and on other US consortia (Branscomb and Keller 1999).

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