Forms and Determinants of R&D Collaborations: Evidence Based on French Data

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ABSTRACT The literature on R&D collaboration highlights a broad set of rationales for allying with other organizations. At the same time, it has been reported that there exists a large variety of forms of collaboration. Nevertheless, the relation between the motives to collaborate and the different forms of collaboration has not been examined. In this paper, we attempt to fill this gap by highlighting and explaining the heterogeneity in the forms of collaboration as a result of several interdependent simultaneous choices. Using a sample of more than 3,000 R&D collaborations, a typology of their characteristics allows us to distinguish five discrete forms of collaboration. Then using a multinomial logit estimation, we show how the forms of collaboration vary according to the firms’ attributes (size, R&D internal effort, group membership), market and objectives pursued. We also obtain new results on the effects of incoming spillovers as well as appropriability conditions.

KEY WORDS: R&D collaborations, collaboration design, cooperative strategies, knowledge spillovers

1. Introduction
In the last two decades, R&D cooperation has attracted a considerable amount of attention. Many empirical studies, in economics or in management, have investigated the motives for and potential benefits of cooperation as compared to internal R&D. Cooperation enables firms to internalize knowledge spillovers, facilitates knowledge transfers between them (in particular between firms and universities), helps them gain access to complementary knowledge and technologies, generates scale economies of research, enables firms to speed the commercialization of new products or technologies, to avoid duplicative R&D efforts, to share costs and risk, to gain access to foreign or new markets (Hagedoorn et al., 2000). Nevertheless, these studies generally suffer from several shortcomings.
In early studies on R&D collaboration, cooperation was most often captured as a homogenous object (i.e. R&D cooperation vs. internal R&D). Yet, observing that the firms involved in R&D collaboration are more and more heterogeneous and that the forms of cooperation are increasingly various, some authors have claimed the need for a more sophisticated and multifaceted approach to R&D cooperation (e.g. Osborn and Hagedoorn, 1997; Veugelers, 1998).

In this way, several studies (e.g. Cassiman and Veugelers, 2002; Kaiser, 2002; Belderbos et al., 2004; Lopez, 2008) show that R&D cooperation determinants strongly vary according to the type of partners (competitor, customer or supplier, academic actors). However, these studies are based on the (implicit) hypothesis that one type of partner is associated to one type of cooperation. In other words, it is presupposed that a firm always follows the same strategy with one type of partner while the results of several studies show that this hypothesis is not satisfactory (see Carayol, 2003 or Levy et al., 2009, in the case of public–private research partnerships; Bonte and Keilbach, 2005, in the case of vertical partnerships).1

Other authors choose to focus on particular forms of arrangement. For instance, Sakakibara (1997) investigates the firms' decision to participate in Japanese R&D consortia sponsored by governmental organizations, while Hernan et al. (2003) study the determinants of firm participation in European Research Joint Ventures. Nevertheless, if they provide new and interesting results, they cannot be generalized to firms' cooperative behaviour unconstrained by (pre-specified) research programmes.

In this paper, our goal is to study those strategies more carefully, explaining the heterogeneity of R&D collaboration. More precisely, we propose a characterization of the diversity of the forms of R&D cooperation and then try to detect differences in the forms of R&D collaboration firms choose to undertake. To this aim, we make use of a French survey of inter-business relationships (ERIE survey), which is unique and particularly well suited to our study since the sample of firms is representative in size, sector and belonging to a group, whether they are innovative or not.

After a synthetic literature review on R&D collaboration forms, we build our dependent variable as the outcome of a typology on selected characteristics. This method allows us to consider the fact that the decision to cooperate encompasses a variety of interrelated (and often) simultaneous choices. Then, using a multinomial logit, we test the influence of a large set of explanatory variables (incoming spillovers, appropriability conditions, size of the firm, R&D intensity of the firm, type of motives, etc.) on the chosen form of collaboration. Our results provide new insight into R&D collaborative strategies and confirm that the choice of the form of cooperation is much more complex than is often described. We show that the forms of collaboration vary strongly according to the firms' attributes (size, R&D internal effort, group membership), market and objectives. We also obtain new results on the effects of incoming spillovers as well as appropriability conditions. They provide some insight into the instability of the results obtained in the literature with respect for instance to the firms' attributes.

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1 Another limitation is linked to the problem of sample selection bias. In particular, the vast majority of studies on cooperative R&D make use of samples of innovative firms (e.g. Community Innovation Survey (CIS) of the European Commission).
The paper is organized as follows. Section 2 provides a review of the theoretical and empirical literature on R&D collaboration forms. The data-set we made use of is described in Section 3. In Section 4, we introduce the empirical strategy we used to characterize the diversity of the forms of R&D cooperation and discuss the typology obtained. Section 5 describes the set of determinants chosen on the basis of our review of the literature and presents the econometric model used to test their influence. The results are presented in Section 6. The last section offers a discussion of these results and of the limitations of our study.

2. How do Firms Collaborate in R&D? A Literature Review

If the number of R&D partnerships has significantly increased in the last 20 years, our knowledge of their form and of the underlying strategies remains limited. Most research studies focus on the type of partners, distinguishing between public-private partnerships, vertical cooperation and horizontal cooperation and find that the motives for cooperation vary strongly with the nature of the partner (e.g. Cassiman and Veugelers, 2002; Miotti and Sachwald, 2003; Belderbos et al., 2004; Bonte and Keilbach, 2005). On the one hand, cooperation with competitors is often motivated by concerns regarding knowledge appropriability (e.g. D’Aspremont and Jacquemin, 1988), knowledge exchange or cost sharing (Miotti and Sachwald, 2003). Vertical collaboration on the other hand can be established with customers or suppliers. Cooperation with customers aims to reduce the risk related to market uncertainty by increasing the probability that the innovation will be a commercial success while collaborations with suppliers aim to secure and increase the quality of firms’ inputs and to benefit from cost reductions through process innovation (Hagedoorn, 1993). Finally, firms form partnerships with universities in order to gain access to knowledge, competencies or equipment possessed by public research institutes or universities. It has been argued that the primary objective is to develop radical product or process innovations (Tether, 2002; Monjon and Waelbroeck, 2003), more specifically when technological uncertainty is strong, in new technological fields (Miotti and Sachwald, 2003; Belderbos et al., 2004).

Nevertheless, beyond the type of partners, there are many possible forms of R&D collaboration, including informal partnerships, subcontracting, research contracts, consortia and research joint ventures. Indeed, while many studies have largely explored the determinants of cooperation according to the type of partner, little is known about the forms of collaboration that are used by firms and about the rationale of the choices.

Equity vs. Contractual Partnerships

A first distinction was made by Hagedoorn (2002). Using 40 years of data on R&D partnerships, he focuses on formal agreements and divides them into two groups: equity-based joint ventures and non-equity contractual partnerships such as joint projects or market transactions. Research joint ventures (RJVs) are common structures jointly controlled by at least two entities (mostly firms). Thus, RJVs can be attractive as they are a
more flexible solution than that of having a fully owned subsidiary (Kogut, 1991). At the same
time, because the parent organizations become highly interdependent, choosing a “good”
partner is essential (Hagedoorn, 2002; Lundin et al., 2005). For this reason, RJVs tend to be
formed within groups of organizations. Moreover, because of their organizational costs and
failure rates, it has been observed that RJVs are now less common than contractual
partnerships (Narula and Hagedoorn, 1999; Nooteboom, 1999; Hagedoorn, 2002;
Sampson, 2004). Asymmetric information partly explains the complexity of this form of
agreement (Ambec and Poitevin, 2008). Hagedoorn (2002) also observes that RJVs are
more common in medium- or low-tech industries.

Non-equity, contractual forms of R&D partnerships tend to be used in the context of
specific projects with shorter time horizons (Hagedoorn, 1993; Contractor and Lorange,
2002). Hagedoorn (2002) finds that, even when the projects have short time horizons, the
commitment of the parties involved can be strong (this is in contradiction with Contractor and
Lorange, 2002). Lundin et al. (2005) describe these forms of cooperation, from market
transactions to joint research projects. Market transactions are often aimed at acquiring
external technology. Such collaborations can also take the form of outsourcing (Narula, 2001,
cited in Lundin et al., 2005). Because they facilitate negotiation and consequently
help reduce transaction costs as well as opportunistic behaviour, patents should promote
market transactions for the acquisition of technology (Arora et al., 2001). Thus the
effectiveness of patents should increase the probability of R&D outsourcing. Moreover,
several studies have shown that in the 1990s R&D-intensive industries started to rely on
outside suppliers in order to innovate (e.g. Brusoni et al., 2001; Mol, 2005). As noted by Mol
(2005), this calls into question the traditional assumption that “under conditions of high
innovation expenditures there are scale, appropriation and opportunism concerns that make
outsourcing a less preferred option” (Mol, 2005: 577). Mol (2005) also finds that uncertainty
(measured as the variance in sales over a five-year period) is negatively correlated with
outsourcing. Joint projects involve companies who have decided to jointly perform R&D, in
new and risky research areas characterized by a high level of uncertainty on the outcome of
the research (Hagedoorn, 2002). Competitors use this form of collaboration to
develop technological breakthroughs involving pre-competitive knowledge or standards
definition (Caloghirou et al., 2003) but it is less used in development stages. Finally, SMEs are
probably not frequently involved in such pre-competitive R&D projects (Lundin et al., 2005).

Formal vs. Informal

Research partnerships can also be informal (Hagedoorn et al., 2000). For instance,
researchers of two firms could exchange technical information without entering into binding
formal contracts. Little information is available about this type of partnership. Moreover,
various forms of undefined arrangements exist (Hagedoorn et al., 2000). Nevertheless,
some works indicate that the percentage of informal collaboration ventures is higher than
that of formal collaborations (Link and Bauer, 1987; Harabi, 1998; Bönte and Keilbach,
2005). Informal collaborations can be formed between different firms but also between

\cite{Boente2005}

For instance, Bönte and Keilbach (2005) report that 70 per cent of the firms in their data-set are engaged in informal
cooporations vs. 40 per cent in formal ones (some of which are also engaged in informal cooporations).
firms and public research institutes or universities which can, according to Hall et al. (1998), play the role of short-term project-specific research subcontractor. We expect the probability of informal cooperations to increase with time constraints and with the fact that it is a flexible way of dealing with disputes between the partners (Bönte and Keilbach, 2005). Finally, one could also expect, in this case, a lesser commitment of private partners in terms of investment for instance.

Multilateral Partnerships

As indicated by Sakakibara (2001), the main goals of R&D partnerships are to share costs and risk, in order to facilitate the implementation of large-scale projects, but also to acquire complementary knowledge and competencies, acquisition which is reinforced by the diversity of the participants in the project, but which is also made difficult when knowledge is highly tacit and fundamental (Polanyi, 1958). In such a configuration (large-scale project, necessity to combine diverse competencies and tacit knowledge), the incentives to form a multi-partnership (e.g. a consortium) are strong.

3. The Data

The data used for our research come from a French survey of inter-business relationships (ERIE survey). They have been collected in early 2003 by the French institutes of statistics. It aimed to provide a large overview of the relations between firms (and other actors) excluding usual relations with client or supplier (e.g. orders by catalogue) and purely financial relations. The sample of 7,611 firms interviewed is representative in size, sector and belonging to a group.3 The survey concentrated on the main aspects of firms’ activities: production, procurement, marketing, R&D and innovation. We focused on this latter activity. Firms were asked to describe no more than three of their strategic relationships. Two types of questions were asked: questions concerning the partner (nature, location, selection criteria, etc.) and questions concerning the relationship itself (duration, nature of R&D, economic rationale for the relationship, outputs, etc.).

Out of all the firms in the sample, we restrict our study to those belonging to the manufacturing sectors for which we have additional data (e.g. R&D expenditures) and having at least one R&D cooperation relationship. It turns out that 1,775 manufacturing firms (23.32 per cent of the total sample)4 have at least one R&D cooperation relationship with another organization. Among firms in the sample that cooperate in R&D with others, almost half of them have only one cooperative relationship. Thus, we are confronted with the fact that a firm can describe one, two or three partnerships with a priori no particular order. In order to solve this problem, we build a new database on relations (and not on firms). The initial database has as many observations as firms interviewed. It is presented in Table 1. For instance, firms A and B only describe one relationship, while firm C describes two

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3 See SESSI (2004) for more information about the characteristics of the respondents.
4 Becker and Dietz (2004) find that about 37 per cent of German firms collaborate with other organizations to jointly develop new products. Tether (2002) finds that 45 per cent of English innovating firms cooperate with other organizations. A total of 18.9 per cent of innovative Spanish firms cooperate (Lopez, 2008).
relationships. We then transform Table 1 into Table 2 in such a manner that the new database has as many observations as there are strategic relationships described by firms. Every observation contains all the information for each relationship and for the partner, as well as the characteristics of the firm that has described this relationship. The sample then contains 3,297 relationships.

As mentioned before, the database gives us information about the characteristics of the relationships and of the partners (from the interviewed firm’s point of view). Unlike the methodology used in other studies on cooperation, the ERIE survey does not allow us to distinguish between types of partners (i.e. cooperation between competitors vs. cooperation between clients and suppliers). The relational variables are used to build a typology of the different forms of cooperation. The second type of variables will allow us to test whether the firms’ characteristics and objectives contribute to explaining the diversity of the relationships. For this second stage of our analysis, we use three other databases. The R&D database 2002, which comes from the French Ministry of Education and Research, provides information on firms’ research expenditures. The Annual Survey of Firms (EAE) 2002 provides us with information about the individual characteristics of firms such as size, sector, turnover, location, etc. Finally, the Community Innovation Survey (CIS3) provides information about spillovers and appropriability conditions at the sectoral level. Merging the new sample of relationships with those databases, we obtain a final sample of 3,072 relationships.

4. Exploring the Variety of R&D Collaboration Forms

4.1 Hypotheses, Variables and Methodology

The literature review outlines the existence of the multiple dimensions—and the various choices related to these dimensions—at the origin of the variety of the forms of R&D
collaboration: the types of partners, types of relationship, time horizon, partners’ commitment in the relation, nature of the research (pre-competitive research vs. development). It also suggests that those characteristics are not independent. Thus, we propose the following set of hypotheses about the relations between the (available) variables:

**Hypothesis 1.** A high level of cooperation between the partners is associated with the existence of a contract or RJV.

**Hypothesis 2.** A high level of relationship-specific investments is associated with the existence of a contract or RJV.

**Hypothesis 3.** When the cooperation between partners is strong, the time horizon of the relationship is longer in the case of an informal relationship.

**Hypothesis 4.** The probability to be engaged in multi-partnerships is higher for pre-competitive R&D and large-scale projects.

Our database enables us to define most of the variables related to those relationships’ characteristics with the exception of the type of partner. Table 3 offers a description of the available variables.

In order to test our hypotheses (and to take into account those interrelations for the next step of our study), we perform a Multiple Correspondence Analysis (MCA) on these variables. MCA is an appropriate methodology for exploring qualitative data and for analysing the relations between more than two categorical variables that can be presented in multi-way contingency tables. We retain four axes for our analysis which account for 41.9 per cent of the total inertia of the data. The coordinates of the individuals (relationships) of the sample on these axes have enabled us to create an Ascending Hierarchical Classification (AHC) that results in the division of the population into five homogeneous classes (with an intra-class variance of 46 per cent and an inter-class variance of 54 per cent).

4.2 Results

The relations between the variables. As Figure 1 shows, the first axis of the MCA (12.2 per cent of the total inertia) accounts for the intensity of the collaboration between the partners. It opposes the relations that involve important joint efforts between the parties to the other
relations (i.e. weak collaborations). Moreover, we have observed that a high level of collaboration is associated with the existence of specific investments and a specific mode of communication. A low level of collaboration is obviously associated with a subcontracting
relation. The second axis (11 per cent of the inertia) opposes the short- to medium-term (< five years) relations—also characterized by the existence of a contract—to the long-term relations that are not formalized by a contract. The third axis (9.7 per cent of the inertia) accounts for the type of research (common research or multi-partnership opposed to the management of a common structure) and the balanced vs. unbalanced nature of the research. Finally, the last axis (9 per cent of the inertia) accounts for the nature of the outputs (pre-competitive projects vs. market-oriented projects) associated with the nature of the research: common research that leads to innovation vs. multi-partnership that leads to patents or co-publication.

Thus we observe that the level of commitment, the duration, the existence of a contract and the number of partners all contribute to differentiating the forms of collaboration. We also validate our hypotheses, with the partial exception of H1 and H2. Indeed, a high level of commitment of the partners is positively associated with the existence of a contract but not with the existence of a RJV.

The characteristics of the collaboration classes obtained. We now discuss the characteristics of each class we obtained. Class 1 relationships can be qualified as long-term relationships for the management of a joint venture and represent 14 per cent of the sample. They are long-term partnerships (as they last more than five years) and their objective is the management of a joint venture (or other type of relations). Class 2 relationships can be qualified as multi-partnerships in upstream research projects and represent 16.4 per cent of the sample. They are generally evenly balanced (in the sense that none of the partners imposes its conditions) and short- or medium-term (less than five years). They mainly consist of fundamental research generally conducted with several partners, within a consortium. They tend to focus on upstream research outputs such as patents, co-publications or software. They do not involve any specific investments or any organizational arrangements (i.e. contract). Class 3 relationships are characterized by joint market-oriented research and represent 27.3 per cent of all relationships and so are the most frequent. They are characterized by common market-oriented research projects leading to the development of new products or processes. They consist of long-term and evenly balanced relations. These relations are also based on a high level of cooperation. Nevertheless, they do not involve specific investments, or any specific communication means, and are not governed by contracts either. The relationships in Class 4 are essentially subcontracting relations. They represent 23.5 per cent of the sample. They are, unsurprisingly, “uneven” power relations (one partner imposes its conditions on the other). These relations are short- or medium-term. Moreover, the relations do not lead to any close cooperation between the parties. Such relationships do not necessitate specific investments or communication means. They lead to market-oriented results. Finally, the relations in Class 5 are contractual relationships based on a high level of collaboration and involvement. They represent 18.8 per cent of the collaborations in our sample. The results of these relationships are varied in nature (co-publications and/or patents and new products or processes or prototypes). These relations differ from other classes in that they are characterized by mechanisms that facilitate and help to manage the cooperation. Thus, a contract is often signed and a specific investment is made by at least one of the partners. A specific mode of communication is adopted. They involve a joint effort of the partners and are therefore based on a high level of collaboration.
5. The Determinants of the Choices of Collaboration Mode

The literature traditionally identifies three categories of factors which can affect motives for entering into collaborative relations: economic rationales (e.g. risk and cost sharing, competencies or knowledge exchange), knowledge spillovers and appropriability conditions, firms’ characteristics (such as absorptive capacity, size and belonging to a group). Nevertheless, it is clearly difficult, in the framework of our study, to make straightforward predictions regarding their effect given the diversity of R&D cooperation profiles. This point is also raised by Belderbos et al. (2004). In order to lay the groundwork for the second step of our study, we propose to follow the traditional line of investigation around these three categories of factors while discussing their relevance and their impact in relation to the types of collaboration we have obtained. Doing this, we introduce in this section a large set of new hypotheses as well as the associated variables. Finally, we present our empirical model.

5.1 Hypotheses and Variables

Economic rationales. The diversity of the rationales to cooperate has been stressed in the economics and management literature. According to the transaction cost theory, cooperation helps reduce opportunism and the risk for the transaction (Williamson, 1991). In the resource-based theory, cooperation allows for the exchange of new and complementary knowledge and skills (Kogut, 1988; Ciborra, 1991; Mitchell and Singh, 1992; Hagedoorn et al., 2000) that cannot be transmitted through market-based transactions. R&D cooperation is then seen as a means to internalize and combine complementary, untradable resources (Barney, 1991). Moreover, compared to R&D projects individually undertaken by firms, cooperative R&D projects are thought to reduce research time (Contractor and Lorange, 1988), costs and associated risks by sharing them with the partners. Finally, R&D alliances are also competitive strategies to gain market share or to build entry barriers (Vickers, 1985; Oxley and Sampson, 2004).

Our data allows us to test four of such motives for cooperation: access to scale economies, to new markets, to competencies and risk sharing. We add two other motives, namely, the absence of equipment and the search for flexibility which should provide additional information on firms’ collaborative strategies. We expect that the motives differently influence each type of cooperation. Thus, we suppose that risk sharing has a positive impact on contractual research, as a contract is a means of reducing uncertainty (Williamson, 1991). We also expect a positive impact on multi-partnership of upstream R&D projects, since basic R&D is characterized by a higher level of uncertainty than applied R&D. On the contrary, if the technologies and R&D processes at stake are sufficiently generic or standardized, the relation is less risky and thus, can take the form of a subcontracting contract (Dhont-Peltrault and Pfister, 2007). Moreover, scale economies, which are a means of reducing R&D costs, are expected to have a positive impact on multi-partnership in upstream R&D projects. Indeed, this type of research can be costly, without necessarily producing usable results. Cooperation could be a means of sharing costs.

Moreover, we expect that access to competencies is an important motive to cooperate, in the case of R&D cooperations whatever their form, because innovation processes are more and more complex and interactive, except in the case of subcontracting. We also
expect that the need to have access to certain types of equipment positively influences R&D subcontracting as well as multi-partnership when the firms need the equipment on an irregular basis and/or when it is very costly. Silipo (2008) considers that a joint venture not only enables the partners to share information, but also to avoid duplicating efforts and to save on costs. Thus, we expect that scale economies and access to competencies positively influence the decision to enter into a joint venture.

Knowledge spillovers and appropriability conditions. The literature in theoretical Industrial Organization considers that R&D cooperation allows firms to internalize knowledge spillovers (e.g. D’Aspremont and Jacquemin, 1988; De Bondt, 1996; Atallah, 2002). Moreover, if firms try to increase incoming spillovers, they also attempt to appropriate the benefits of their innovations by controlling information flows out of the firm (Belderbos et al., 2004), in order to reduce outgoing spillovers. Indeed, imperfect appropriability increases the cooperating firms’ temptation to free ride on each other’s R&D investments (e.g. Shapiro and Willig, 1990) and encourages outsiders to free ride on the R&D efforts of the cooperation partners (Greenlee and Cassiman, 1999). Thus firms are likely to take into account appropriability conditions when entering into cooperation agreements (Bonte and Keilbach, 2005). The results of empirical studies on the role of both knowledge appropriability and of knowledge spillovers on the choice of cooperation relationships are contradictory and strongly depend on the types of partners (see, for instance, Cassiman and Veugelers, 2002; Kaiser, 2002; Hernan et al., 2003; Belderbos et al., 2004).

We build spillover variables at the 3-digit industry level. We create three variables of spillovers which respectively measure the importance of public sources to innovate (such as professional conferences, meetings, journals, fairs and exhibitions), of institutional sources coming from universities and public research organizations and of internal information (marketing, R&D, etc.) used in the innovation process. Finally, we include two measures of appropriability at the 3-digit industry level: a measure of the importance of the strategic protection (such as secret, complexity, lead time) and a measure of the importance of legal protection (patents). According to the literature, we expect that the effectiveness of patents has a positive influence on the decision to subcontract. We also expect that the level of strategic protection could have a negative impact on collaborative research which implies knowledge sharing as, in this type of cooperation, there is no contract or incentive that enables those involved to effectively prevent free-rider behaviour. On the contrary, internal competencies should be important for collaborative research or multi-partnership.

Firms’ characteristics. In the economic literature, firms’ size partly explains their strategies and behaviours. Link and Bauer (1987), Vonortas (1997), Fritsch and Lukas (2001) and Tether (2002) find that size, measured by the number of employees, increases the propensity to cooperate. However, this relation is not so obvious. Indeed, small firms might have a greater need for cooperative agreements because in general they have fewer internal resources. But whilst large firms have greater internal resources, they are also likely

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5 The introduction of spillovers at the firm level can generate potential endogeneity problems (Belderbos et al., 2004; Lopez, 2008). We suppose that this problem is smaller as the strategy of one firm should not strongly modify the industry variable.
to engage in a wider range of activities, including some that might benefit from cooperation (Tether, 2002). The firm’s size itself therefore gives little indication as to whether or not firms might engage in cooperative arrangements. Rather it is because the size of the firm proxies for (market) power that it is likely to influence the configuration of such arrangements (Tether, 2002). Moreover, Kleinknecht and Van Reijnen (1992) confirm that this hypothesis must be considered with caution as their results show that the firm’s size has no significant influence on the probability of R&D cooperation.

The second characteristic to be considered is the R&D intensity. One can expect R&D intensity to impact positively on the probability of cooperating. One of the reasons for this is that R&D intensity is indicative of firms’ ability to absorb external knowledge (Cohen and Levinthal, 1990) and to identify new technological opportunities (Negassi, 2004). Thus, firms conduct R&D partly in order to increase their absorptive capacity and to take optimal advantage of their environment and thus of their partners’ knowledge through R&D cooperation. As in the case of the firm’s size, empirical results vary. For instance, König et al. (1994) and Lopez (2008) find no significant relationship between R&D intensity and cooperation while Vonortas (1997) concludes that cooperation is linked to R&D intensity in only one of his five industrial sectors. Fritsch and Lukas (2001), Becker and Dietz (2004) and Negassi (2004) show a positive impact of R&D intensity on R&D cooperation.

Belonging to a group may influence the firms’ propensity to cooperate. Firms that belong to large groups are, on the one hand, able to draw on resources from within their group and might therefore, not need to seek as many resources externally; on the other hand, firms that belong to groups have access to important resources that enable them to diversify the risk (through their projects portfolio) and benefit from the group’s reputation. Empirical models find that belonging to a group has a positive effect on the probability to cooperate (Kleinknecht and Van Reijnen, 1992; Tether, 2002; Negassi, 2004).

To test the role of a firm’s characteristics, we include R&D intensity (the logarithm of the R&D expenditures of the firm). Increasing levels of R&D intensity are expected to be correlated with absorptive capacity. We expect a positive impact of R&D, especially in cases of cooperation for fundamental research, as this type of research often requires a greater absorptive capacity. In order to test if the choice of cooperation mode depends on the size of the firms or on their position in the market, we also introduce the market share and the size of the firm (the logarithm of the number of employees). We expect a positive impact of the size on the multi-partnerships in upstream research as the medium and large firms are more oriented towards upstream research than SMEs are. We also expect a positive impact on RJV as Hernan et al. (2003). On the contrary, we expect a negative impact of the size on subcontracting (Kimura, 2001). Finally, the group variable indicates whether the firm is independent or belongs to a French or a foreign group. We do not have any expectation on the influence of belonging to a group on the choice of a type of cooperation as the literature does not provide consistent results in this regard.

Finally, concerning the firm’s characteristics, and in order to better understand the impact of the firm’s activities on this decision to cooperate, we also introduce a variable to indicate if the firm has a market-oriented role, a research-oriented role or both in the relationship. We expect that the multi-partnership in upstream R&D projects is positively influenced by the research-oriented role of the firms as a consortium is generally a pre-competitive form of collaboration. Inversely, we expect that when the firm has a
market-oriented role in the relationship, the cooperation in which it is involved takes the form of a subcontracting relationship.

Table A1 in the Appendix describes the explanatory variables we used and their method of calculation. Table A2 displays descriptive statistics of these variables.

5.2 The Model

The multinomial logit model is seen as a generalization of the binary logit model with a polytomous and unordered dependent variable. It is a non-linear model that enables us to examine the probabilities of the \((m + 1)\) different values of the dependent variable \(y\). The relative choices can be defined as follows:

\[
p_j = \Pr(y_i = j) = \frac{\exp(x_i \beta_j^*)}{1 + \sum_{k=1}^{m} \exp(x_i \beta_k^*)}
\]

with \(\beta_j^* = \beta_j - \beta_0, \forall j = 1, 2, \ldots, m\). This formulation enables us to follow the constraint \(\sum_{k=0}^{m} \rho_k = 1\) and the estimated parameters must be interpreted in relation to the reference group (i.e. to value \(m = 0\)).

The estimation of the model is then performed by maximizing the log-likelihood function with respect to the vector of parameters \((\beta_1, \ldots, \beta_m)\). This function is formulated as follows:

\[
\log(L) = \sum_{i=1}^{N} \sum_{k=1}^{m} y_{ik} x_i \beta_k - (m + 1) \sum_{i=1}^{N} \log \left(1 + \sum_{k=1}^{m} \exp(x_i \beta_k)\right).
\]

In our case, the choice between \(j\) forms of collaboration is determined by the net profit expected by firm \((i)\) from this form of cooperation \((j)\). Belonging to Class 4 corresponds to the reference value of the explained variable.\(^6\)

The results of the multinomial logit estimation are presented in Appendix, Table A3. It should also be noted that a Wald test rejects the null hypothesis that these categories can be collapsed (see Appendix, Table A5) indicating that significant differences between these cooperation strategies exist. We also have tested the validity of the independence of irrelevant alternatives (IIA) assumption since it is essential for the appropriateness of the multinomial logit model. We have employed a Hausman-type test provided by Hausman and McFadden (1984) which compares the estimated coefficients of a model using all three categories and a subset where one of the categories is excluded (see Bönte and Keilbach, 2005). We extended the model with five categories. If the IIA assumption holds, then the estimation of the restricted and the unrestricted model should provide similar estimates. The test suggests that the null hypothesis of the IIA assumption cannot be rejected for each of the categories. As the Chi\(^2\) is negative when Class 2 and Class 3 are separately excluded.

\(^6\)Since individuals of our data-set are firms’ relations and since a firm can describe several relations, we make use of the cluster option in Stata. We also ran a regression with data clustered by sector. Effects remained unchanged. Notice that, in addition, we have no way of knowing whether the same partnership has been surveyed on both sides of the relation. This may introduce another kind of within group effect which we cannot treat here (we thank a referee for this remark).
(see Appendix, Table A6), we performed another Wald test based on seemingly unrelated estimates. The results of this test confirm that the IIA hypothesis is not violated.

6. Results and Discussion

Table A3 (in the Appendix) presents the results of the multinomial logit estimation, where Class 4 serves as reference. This means that the significance and sign of the coefficient need to be interpreted relative to this class. Since such relative probabilities are hard to interpret, we choose to discuss the marginal effects of the explanatory variables on the probabilities of each cooperation type. These results are displayed in Table 4.

They can be interpreted as the variation, in percentage, in the probability of choosing a particular form of cooperation given a 1 per cent deviation from the mean for continuous variables and the percentage point variation in the probability of entering a form of cooperation if a dummy variable changes from 0 to 1. We discuss the results for each explanatory variable.

Economic rationales. Our results confirm that the type of cooperation chosen depends on the reasons that lead the firm to cooperate. The need for scale economies explains a multi-partnership in upstream research and a contractual relationship based on a strong collaboration and involvement. This result confirms our hypothesis about multi-partnership (Sakakibara, 2001) but shows the impact on contractual cooperation. Conversely, it does not have any significant impact on the probability of entering into a joint venture—contrary to Silipo’s result (2008)—or into a joint research project. Finally, firms that seek to realize scale economies have a lower probability of engaging in subcontracting cooperation. Thus, the wish to benefit from scale economies could explain the decision to enter into cooperative relationships that require important investments or those in which an upstream research project is undertaken.

Firms that wish to gain access to new markets are less likely to choose to enter into a joint venture or a subcontracting relation. They prefer a contractual relationship based on strong collaboration and involvement. The contract can explicitly define the market-sharing rules and rights, which are essential for innovation activities.

A shortage of skills can lead firms to choose a multi-partnership in upstream research or a contractual relationship based on strong collaboration and involvement, which confirms our hypothesis. However, contrary to what we expected, this motive reduces the probability of opting for a joint venture and for a joint market-oriented research project. The search for complementary skills seems to be related to upstream research cooperation. When firms conduct market-oriented research they do not cooperate because of a lack of competencies. The non-significant impact of the shortage of skills on subcontracting relationships confirms that knowledge is more difficult to transfer through market transactions (Kogut, 1988).

A lack of equipment leads firms to choose a subcontracting relation or a contractual relationship based on strong collaboration and involvement. It seems difficult to consider these two types of relations as similar. Rather, it seems that when firms do not possess the equipment or the skills they need for a particular project, they opt for contractual relationships with firms that do possess these needed resources. The absence of equipment clearly favours the subcontracting option. This result is in keeping with the transaction cost
theory (Williamson, 1991) which considers that when the transaction is rare and the specificity of the asset is high, subcontracting can be an alternative to insourcing. An absence of equipment reduces the probability of choosing the other three types of relations. This result is surprising in that we had expected that partnerships with universities were undertaken in order to gain access to equipment firms do not possess.

The wish to increase flexibility does not influence the choice of relationship, except in the case of common market-oriented research. In this case, this reason reduces the probability to choose this type of relation. Flexibility, which can be an important factor in production, does not seem to be important in R&D cooperation choices.

Our results confirm that relations can take different forms according to the determinants of cooperative arrangements for innovation. They contribute to a better understanding of the motives of cooperation. Thus cost sharing and skills complementarity are not always the main reasons for initiating a relationship; it all depends on the types of cooperation.
Moreover, our results highlight that the reasons for cooperating are not exclusive, as shown by Sakakibara (1997) and Tether (2002).\footnote{Notice that we also tested the influence of the geography on the relations but couldn’t find any significant effects. The proximity of the partner is never a main determinant for the choice of the partner. We simply observed that subcontracting relations are often national or regional while the partner for the management of a joint venture is often an affiliate of a foreign group.}

**Knowledge spillovers and appropriability conditions.** There is little evidence that institutional spillovers at industry level have a significant impact on the probability of choosing one specific type of cooperation. We note one exception, as institutional spillovers reduce the probability to choose multi-partnerships in upstream research. As many partners in such type of cooperation are public laboratories, this result could then indicate that when firms can easily benefit from institutional spillovers they do not need to cooperate with a university. This result differs from that of Belderbos et al. (2004) who find that institutional spillovers positively influence cooperation whatever the type of partner. Thus institutional spillovers have different impacts on the collaborative strategies.

Public spillovers have a positive impact on the probability to choose a multi-partnership in upstream research. This result is similar to that of Lopez (2008) on the role of public spillovers on cooperation with research institutions. Public spillovers influence negatively the probability of choosing common market-oriented research. This result is surprising as in the literature a positive (or non-significant) impact of public spillovers is traditionally expected. This result can be compared to that concerning institutional spillovers in upstream cooperation. Indeed, as we use a variable at the industry level, when the level of spillovers is high, the need to cooperate could be reduced; free-riding behaviour could be more important, as firms know that they will benefit from spillovers anyway. Here the spillovers occur further downstream than in the previous case. Finally, other types of cooperation are not influenced by public spillovers. This confirms Belderbos et al.’s (2004) and Bönte and Keilbach’s results (2005). For these types of cooperation the public spillovers are not criteria of choice.

The level of internal effort in R&D is not significant except in the case of common market-oriented research. This means that the choice of a type of cooperation is not based on the firm’s level of R&D but that in some cases, this choice is related to the organizational structure of knowledge transfer within firms.

Strategic protection at the industry level positively influences the probability of developing a joint venture. In this case, the firm is able to protect internally its knowledge. Bönte and Keilbach (2005) find a similar result for firms that develop formal cooperative relationships. Strategic protection has a negative impact on the probability to choose common market-oriented research, confirming our hypothesis. Finally, the other types of cooperation are not impacted.

Legal protection at the industry level has, on the whole, no impact on the probability to choose one type of cooperation. This confirms the results proposed by Belderbos et al. (2004), Bönte and Keilbach (2005) and Lopez (2008). However, legal protection has a positive impact on the probability of engaging in subcontracting cooperation. In a context where legal protection is high, subcontracting is a privileged option (it is not a risky strategy
since if sensitive knowledge or know how are protected, the risk of opportunism by the subcontractor is reduced). This confirms our hypothesis.

Finally, we suppose that sector-based specificities could play an important role in the choice of the type of cooperation. Indeed, the variables defined at the industry level have, in four of the classes, the strongest impact on the choice of the collaboration mode. Further research in this direction is needed.

Firm-specific characteristics. The results show that the R&D level does not have any significant impact on the choice of type of cooperation, with the exception of the joint venture. In this case, the less the firms invest in R&D, the more likely they are to engage in a common venture. This could be a means for non-R&D firms to jointly develop R&D activities following a strategy that aims to focus on core business or competencies. Our results seem to show that the level of R&D is rarely significant in the choice of collaboration forms, the R&D would not be a discriminant factor in the choice of the collaboration mode. This is in keeping with the results obtained by Kleinknecht and Van Reijnen (1992) and Lopez (2008). Thus, contrary to our hypothesis, it seems that R&D expenditures generally have an effect on the decision to collaborate in R&D or not (Negassi, 2004), but they do not influence the choice of the form of collaboration.

The size of the firms positively influences the decision to develop a multi-partnership in upstream research and a contractual relationship based on a high level of collaboration and involvement. This result confirms our proposition about the link between size and upstream research. Firms that undertake cooperation in upstream research activities are more likely to be big firms. On the other hand, the size has a negative impact on the decision to subcontract: the subcontracting solution is more likely to be chosen by small firms. This last result confirms that of Kimura (2002). More generally, our results are in keeping with those provided by the literature, concerning the unstable impact of the size on the decision to cooperate. Indeed, by distinguishing five types of cooperation modes, we observe the diversity found in other studies: positive impact, negative impact or no impact. The market share does not have any impact on the type of cooperation. This result invalidates our hypothesis that the choice of cooperation mode sometimes depends on the market structure and sometimes on the size of the firm.

Belonging to a group does not generally have any influence on the type of cooperation selected. This result is consistent with Tether’s results (2002). Similarly, we note that the group variable has a significant impact in two cases that are worth mentioning. Firstly, firms that belong to a foreign group have a high probability of developing a joint venture. This result confirms the strategic importance of the choice of partner in RJV. Secondly, firms that belong to a group (French or foreign) have a low probability of engaging in subcontracting relationships. In this type of relations, descriptive statistics indicate that firms are either the ones that hire a subcontractor or are the subcontractor themselves.

The activities of the firm in the cooperation project influence the choice of type of relationship. In particular, we observe that RJVs are undertaken when the firms’ activities are market oriented. This result is in line with that of the negative impact of R&D on

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8We have tested the non-linearity effect of the size. The results show that there is no such effect.
the choice of RJV. Firms that conduct upstream activities are more likely to choose a multi-partnership in upstream research, confirming our hypothesis on the pre-competitive activities in this form of cooperation. When firms perform both activities, they are more likely to undertake a common market-oriented research or a contractual relationship based on a high level of collaboration and involvement. More surprisingly, the nature of the activities does not impact the decision to subcontract. This result partly confirms that the external subcontractor enables firms to innovate (Mol, 2005). Thus this activity would be present at every stage of the innovation process, according to the need of the partners.

We can conclude that the type of cooperation chosen is little influenced by the characteristics of the firms—with the exception of the firm’s size and the role of the firm in the relation. This result can be linked to the fact that firms can have different needs, which require different forms of cooperation. We suppose that these variables have a more important impact on the decision to cooperate or not to cooperate. However we expected a stronger impact of the R&D level. This means that, with the exception of RJVs, the forms of cooperation do not depend on the level of R&D.

7. Conclusion

In this paper, we have examined the various forms of R&D partnerships and the motivations underlying firms’ choices of forms of cooperation. Thanks to a rich survey on (French industrial) firms’ research and innovation relations, we first study the heterogeneity of such relations, using a typology on their various characteristics. The latter synthesizes the close and complex relationships between the variables we selected on the basis of a literature review: level of commitment in the relation, existence of a contract, duration, number of partners, nature of the research. Then using a multinomial logit estimation, we show how this diversity of partnerships is explained by the attributes of the firms, their market or sector and the objectives pursued.

If we summarize our results by type of collaboration, we find that the probability of developing a joint venture is positively influenced by the level of strategic appropriability and the fact that the firm in this case often belongs to a foreign group. It is also reduced when firms cooperate in order to gain access to new markets, or to the competences or equipment of the partners. Interestingly, the probability of choosing this strategy is negatively influenced by the level of R&D. This result shows that, contrary to what is traditionally expected, RJVs are not generally undertaken in order to reduce risk. Moreover, this form of cooperation has become less widespread than it used to be (it only represents 14 per cent of our sample of relations).

The probability of choosing a multi-partnership in upstream research is positively influenced by the size of the firm and the level of public spillovers at the industry level. Such relationships rather aim to realize economies of scale and to compensate for a lack of competencies. Moreover, firms choose a multi-partnership in upstream research when they perform fundamental activities and if institutional spillovers are low. Thus, these forms of

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9 The strong correlation between the joint venture and belonging to the same group seems to indicate that the research joint venture often represents intra-group relations.
The probability of choosing a common market-oriented research is positively affected by the level of internal sources of knowledge at industry level and by the fact that the firm is active both in downstream and upstream research activities. On the contrary, it is reduced when the level of public spillovers or the strategic protection increases or when firms cooperate to gain access to competencies, equipment and flexibility. This type of cooperation is then strongly chosen according to the nature of spillovers and the appropriability condition at the industry level. We can suppose that it could be specific to some particular sectors.

Firms develop subcontracting relationships in order to compensate for a lack of equipment and when the legal protection at industry level is high. These results show the importance of the level of legal protection in subcontracting relationships to avoid unwanted knowledge disclosure. Finally, the firms that subcontract are not firms that do not perform R&D, as was traditionally considered.

The probability of initiating a contractual relationship based on a high level of collaboration and involvement is positively influenced by the size of the firm, its activities (market oriented and/or research oriented) and the existence of a shared risk. These results confirm the strong link between risk and contracting. It is also influenced by several cooperation objectives such as realizing scale economies, gaining access to new markets, and compensating for a lack of competencies and equipment.

All in all, our results show the advantage of disaggregating the analysis of R&D cooperation according to different forms of collaboration. Indeed, there are important differences in the motives and determinants of the different types of cooperation. Thus, R&D collaboration appears to be a much more sophisticated phenomenon than literature generally suggests. Thus, this study provides indications for building richer and more accurate surveys. It also calls for new theoretical models that incorporate richer aspects of R&D collaboration.

Nevertheless, our work also suffers from several limitations. In comparison to other studies, full information on the nature of the partners is not available. Moreover, we also face a selection bias since our population consists in collaborative firms. Thus, we cannot adequately analyse the first step of the decision, that is, the decision to cooperate (vs. or not). Indeed, we do not know if some companies do not cooperate in R&D because they did not want to (e.g. they only carry internal R&D activities) or cannot or because they do not seek to innovate (in which case they have no incentive to cooperate in R&D). Finally, this survey on R&D collaboration, as many others, only provides us a single data cross section. This implies that firms’ unobservable characteristics cannot be controlled for. Furthermore, the non-renewal of this survey prevents us from studying the dynamics of our cross-sectional population of cooperative firms. This also prevents us from controlling for the impact of recent French innovation policies (for instance, on clusters) on how firms cooperate. In particular, since 2002/2003 (the survey years), one can expect that the weight of multi-partnerships has increased (at least).

Beyond these difficulties, examining the complementarities between those R&D relations would be an interesting direct extension of this study. We could also test the effect

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10 In the same way, firms in CIS surveys are not interviewed on their cooperations if they do not innovate.
of this potential complementarity on firms’ performance for instance on innovation output or on labour productivity (in the vein of Belderbos et al., 2004). This could allow us to identify good practices and thus to provide better foundations for (French) public policies which today mainly encourage one type of cooperation (multi-partnerships).

More generally, we could notably analyse the network of relationships that a firm develops and its impact. Indeed, beyond the collaboration itself, the own collaboration network of a firm’s partners may constitute an element of choice, since it also provides resources in terms of external knowledge through spillovers. This also constitutes a challenging direction for future research. Finally, it might be very interesting to learn more about the reason for cooperation failures which rate, according to the literature, strongly increases. As noted by Veugelers (1998), the incentives to not join or break up a relationship need to be included in the studies on R&D collaboration.

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References

Ambec, S. and Poitevin, M. (2008) Organizational design of R&D activities. Inra-Lema Working Paper, Toulouse.

Arora, A., Fosturi, A. and Gambardella, A. (2001) Markets for technology and their implications for corporate strategy, *Industrial and Corporate Change*, 10(2), pp. 419–451.

Atallah, G. (2002) Vertical R&D spillovers, cooperation, market structure and innovation, *Economics of Innovation and New Technology*, 11(3), pp. 179–209.

Barney, J. (1991) Firm resources and sustained competitive advantage, *Journal of Management*, 17(1), pp. 99–120.

Becker, W. and Dietz, J. (2004) R&D cooperation and innovation activities of firms: evidence for the German manufacturing industry, *Research Policy*, 33, pp. 209–223.

Belderbos, R., Carree, M., Diederen, B. and Lokshin, B. (2004) Heterogeneity in R&D cooperation strategies, *International Journal of Industrial Organization*, 22, pp. 1237–1263.

Bönte, W. and Kelbach, M. (2005) Concubinage or marriage? Informal and formal cooperations for innovation, *International Journal of Industrial Organization*, 23, pp. 279–302.

Brusoni, S., Prencipe, A. and Pavitt, K. (2001) Knowledge specialization, organizational coupling, and the boundaries of the firm: why do firms know more than they make?, *Administrative Science Quarterly*, 46(4), pp. 597–621.

Caloghirou, Y., Ioannides, S. and Vonortas, N. S. (2003) Research joint ventures, *Journal of Economic Surveys*, 17(4), pp. 541–570.

Carayol, N. (2003) Objectives, agreements and matching in science–industry collaborations: reassembling the pieces of the puzzle, *Research Policy*, 32, pp. 887–908.

Cassiman, B. and Veugelers, R. (2002) R&D cooperation and spillovers: some empirical evidence from Belgium, *American Economic Review*, 92(4), pp. 1169–1184.

Ciborra, C. (1991) Alliances as learning experiments: co-operation, competition and change in high tech industries, in: L. Mytelka (Ed.), *Strategic Partnerships, States, Firms and International Competition*, pp. 51–77 (London: Frances Pinter).

Cohen, W. M. and Levinthal, D. A. (1990) Absorptive capacity: a new perspective on learning and innovation, *Administrative Science Quarterly*, 35(1), pp. 128–152.

Contractor, F. J. and Lorange, P. (1988) Why should firms cooperate? The strategy and economics basis for cooperative ventures, in: F. J. Contractor & P. Lorange (Eds), *Cooperative Strategies in International Business*, pp. 3–31 (Lexington, MA: Lexington Books).

Contractor, F. J. and Lorange, P. (2002) The growth of alliances in the knowledge-based economy, *International Business Review*, 11(4), pp. 485–502.
D'Aspremont, C. and Jacquemin, A. (1988) Co-operative and non-cooperative R&D in duopoly with spillovers, *American Economic Review*, 78(5), pp. 1133–1137.

De Bondt, R. (1996) Spillovers and innovative activities, *International Journal of Industrial Organisation*, 15, pp. 1–28.

Dhont-Petrau, E. and Pfister, E. (2007) R&D cooperation versus R&D subcontracting: empirical evidence from French survey data. Working Paper BETA (Bureau d’Economie Théorique et Appliquée) n° 2007–17, University de Strasbourg.

Fritsch, M. and Lukas, R. (2001) Who cooperates on R&D?, *Research Policy*, 30, pp. 297–312.

Greenlee, P. and Cassiman, B. (1999) Product market objectives and the formation of research joint ventures, *Managerial and Decision Economics*, 20(3), pp. 115–130.

Hagedoorn, J. (1993) Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences, *Strategic Management Journal*, 14(5), pp. 371–385.

Hagedoorn, J. (2002) Inter-firm R&D partnerships: an overview of major trends and patterns since 1960, *Research Policy*, 31, pp. 477–492.

Hagedoorn, J., Link, A. and Vonortas, N. (2000) Research partnerships, *Research Policy*, 29(4), pp. 567–586.

Hall, B. H., Link, A. N. and Scott, J. T. (1998) *Universities as partners in ATP-funded research projects*. Report to the Advanced Technology Program, UC Berkeley, Oxford University, University of North Carolina, and Dartmouth College.

Harabi, N. (1998) Innovation through vertical relations between firms, suppliers and customers: a study of German firms, *Industry and Innovation*, 5(2), pp. 157–179.

Hausman, J. and McFadden, D. (1984) Specification tests for the multinomial logit model, *Econometrica, Econometric Society*, 52(5), pp. 1219–1240.

Hernan, R., Marin, P. and Siotis, G. (2003) An empirical evaluation of the determinants of research joint venture formation, *The Journal of Industrial Economics*, 51, pp. 75–89.

Kaiser, U. (2002) An empirical test of models explaining research expenditures and research cooperation: evidence for the German service sector, *International Journal of Industrial Organization*, 20, pp. 747–774.

Kimura, F. (2002) Subcontracting and the performance of small and medium firms in Japan, *Small Business Economics*, 18, pp. 163–175.

Kleinknecht, A. and Van Reijnen, J. (1992) Why do firms co-operate on R&D? An empirical study, *Research Policy*, 21, pp. 347–360.

Kogut, B. (1998) Joint ventures: theoretical and empirical perspectives, *Strategic Management Journal*, 9(4), pp. 319–332.

Kogut, B. (1991) Joint ventures and the option to expand and acquire, *Management Science*, 37(1), pp. 19–33.

König, H., Licht, G. and Staat, M. (1994) R&D co-operation and innovation activity, in: B. Gahlen, H. Hesse & H. J. Ramser (Eds), *Europäische Integrationsprobleme aus wirtschaftswissenschaftlicher Sicht*, pp. 219–242 (Tübingen: Siebeck).

Levy, R., Roux, P. and Wolff, S. (2009) A study of science–industry collaborative patterns in a large European university, *Journal of Technology Transfer*, 34(1), pp. 1–23.

Link, A. and Bauer, L. (1987) An economic analysis of co-operative research, *Technovation*, 6(4), pp. 247–260.

Lopez, A. (2008) Determinants of R&D cooperation: evidence from Spanish manufacturing firms, *International Journal of Industrial Organization*, 26(1), pp. 113–136.

Lundin, P., Frinking, E. and Wagner, C. (2005) *International collaboration in R&D, structure and dynamics of private sector actors*. Interim report I, Gaia Group Oy, Helsinki.

Miotti, L. and Sachwald, F. (2003) Co-operative R&D: why and with whom? An integrated framework of analysis, *Research Policy*, 32, pp. 1481–1499.

Mitchell, W. and Singh, K. (1992) Incumbents’ use of pre-entry alliances before expansion into new technical sub-fields of an industry, *Journal of Economic Behaviour and Organisation*, 18(3), pp. 347–372.

Mol, M. J. (2005) Does being R&D intensive still discourage outsourcing? Evidence from Dutch manufacturing, *Research Policy*, 34, pp. 571–582.

Monjon, S. and Waelbroeck, P. (2003) Assessing spillovers from universities to firms: evidence from French firm-level data, *International Journal of Industrial Organization*, 21, pp. 1255–1270.

Narula, R. (2001) Choosing between internal and non-internal R&D activities: some technological and economic factors, *Technology Analysis & Strategic Management*, 13, pp. 365–387.

Narula, R. and Hagedoorn, J. (1999) Innovating through strategic alliances: moving towards international partnerships and contractual agreements, *Technovation*, 19(5), pp. 283–294.

Negassi, S. (2004) R&D co-operation and innovation microeconomic study on French firms, *Research Policy*, 33, pp. 365–384.

Nootenboom, B. (1999) Innovation and inter-firm linkages: new implications for policy, *Research Policy*, 28(8), pp. 793–805.
Osborn, R. N. and Hagedoorn, J. (1997) The institutionalization and evolutionary dynamics of interorganizational alliances and networks [Special research forum on alliances and networks], The Academy of Management Journal, 40(2), pp. 261–278.

Oxley, J. E. and Sampson, R. C. (2004) The scope and governance of international R&D alliances, Strategic Management Journal, 25, pp. 723–749.

Polanyi, M. (1958) Personal Knowledge: Towards a Post-Critical Philosophy (Chicago: University of Chicago Press).

Sakakibara, M. (1997) Heterogeneity of firm capabilities and cooperative research and development: an empirical examination of motives, Strategic Management Journal, 18, pp. 143–164.

Sakakibara, M. (2001) The diversity of R&D consortia and firm behavior: evidence from Japanese data, The Journal of Industrial Economics, 49(2), pp. 181–196.

Sampson, R. C. (2004) Organizational choice in R&D alliances: knowledge based and transaction cost perspectives, Managerial and Decision Economics, 25, pp. 421–436.

SESSI (Service des études et des statistiques industrielles) (2004) Inter-business relations: numerous and primarily within France, Le 4 Pages, n° 195. Available at: http://www.insee.fr/sessi/4pages/pdf/4p195A.pdf (accessed November 2004).

Shapiro, C. and Willig, R. (1990) On the antitrust treatment of production joint ventures, Journal of Economic Perspectives, 4, pp. 113–130.

Silipo, D. B. (2008) Incentives and forms of cooperation in research and development, Research in Economics, 62, pp. 101–119.

Tether, B. S. (2002) Who cooperates for innovation, and why? An empirical analysis, Research Policy, 31, pp. 947–967.

Veugelers, R. (1998) Collaboration in R&D: an assessment of theoretical and empirical findings, De Economist, 146(3), pp. 419–443.

Vickers, J. (1985) Pre-emptive patenting, joint ventures and the persistence of oligopoly, International Journal of Industrial Organization, 3(3), pp. 261–273.

Vonortas, N. S. (1997) Co-operation in Research and Development (Boston: Kluwer Academic).

Williamson, O. E. (1991) Comparative economic organization: the analysis of discrete structural alternatives, Administrative Science Quarterly, 36(2), pp. 269–296.
### Appendix

**Table A1. The variables of the multinomial logit**

| Explained variable | Definition | Derived from: |
|--------------------|------------|---------------|
| Typcoop            | 5-modalities variable, obtained through a typology (cf. Section 4). | ERIE (Enquête sur les Relations Inter-Entreprises) 2003 |

**Explicative variables**

At the (respondent) firm level

| | Definition | Derived from: |
|---|------------|---------------|
| R&D | Logarithm of R&D expenses. | R&D survey (Enquête R&D) 2002 |
| Size | Logarithm of number of employees. | EAE (Enquête Annuelle d’Entreprises) 2002 |
| Part group | 1 if the firm is part of a domestic group, 2 if the firm is part of a foreign group, 0 otherwise. | Financial Links (Liaisons Financières) 2002 |
| Market shares | Share of the company’s total sales on total sales of the industry of the French territory. | EAE 2002 |
| Risk | Shared risk in the relation: 1 if yes, 0 otherwise. | ERIE Survey 2003 |

Based on the following question in the survey: “Is the risk-taking shared with your partner?”

| Role in the relation | Definition | Derived from: |
|----------------------|------------|---------------|
| Market oriented | Market-oriented role of the firm (industrial development and/or production). | ERIE Survey 2003 |
| Mixed | Mixed role of the firm (industrial development and/or production and research and/or experimental development). | ERIE Survey 2003 |

Based on the following question in the survey: “Specify the role you insure in the relation: research, experimental development, industrial development or production” (non-exclusive choices).

| Motives for the formation of the relation | Definition | Derived from: |
|----------------------------------------|------------|---------------|
| Scale economies | 1: search for scale economies (0 otherwise). | ERIE Survey 2003 |
| New markets | 1: access to new markets (0 otherwise). | ERIE Survey 2003 |
| Competencies | 1: search for complementary competencies (0 otherwise). | ERIE Survey 2003 |
| Equipment | 1: absence of equipment (0 otherwise). | ERIE Survey 2003 |
| Flexibility | 1: search for flexibility (0 otherwise). | ERIE Survey 2003 |

Based on the following question in the survey: “What are the main two reasons for which you participate in this relationship?”
Table A1. Continued

| Definition                                                                 | Derived from:                        |
|--------------------------------------------------------------------------|--------------------------------------|
| At the (respondent) firm’s industry level                                |                                      |
| Institutional incoming spillovers Mean score at the firm’s industry level* of the importance of universities and non-profit research institutions as source of knowledge for innovation. | CIS3 survey 2000                     |
| Public incoming spillovers Mean score at the industry level* of the importance of professional conferences, meetings, journals, fairs, exhibitions as source of knowledge for innovation. | CIS3 survey 2000                     |
| Internal sources Mean score at the industry level* of the importance of internal source for innovation. | CIS3 survey 2000                     |
| Strategic protection Mean score at the industry level* of effectiveness of secrecy, complexity and/or lead time as a protection measure of innovation. | CIS3 survey 2000                     |
| Legal protection Mean score at the industry level* of effectiveness of patents and registration of brands as a protection measure of innovation. | CIS3 survey 2000                     |

*3-digit Nace.

Table A2. Descriptive statistics

| Variables                          | No. of obs. | Mean   | Std. dev. | Min | Max  |
|------------------------------------|-------------|--------|-----------|-----|------|
| Log R&Dexp                         | 3,072       | 3.968  | 4.198     | 0   | 13.647 |
| Size                               | 3,072       | 5.199  | 1.563     | 0   | 11.331 |
| Part group                         | 3,072       | 1.069  | 0.748     | 0   | 2    |
| Market shares                      | 3,072       | 0.047  | 0.111     | 0   | 1    |
| Risk                               | 3,072       | 0.128  | 0.334     | 0   | 1    |
| Firm’s role in the relation        | 3,072       | 1.906  | 0.732     | 1   | 3    |
| Motives                            |             |        |           |     |      |
| Scale economies                    | 3,072       | 0.151  | 0.358     | 0   | 1    |
| New markets                        | 3,072       | 0.229  | 0.420     | 0   | 1    |
| Competencies                       | 3,072       | 0.405  | 0.491     | 0   | 1    |
| Equipment                          | 3,072       | 0.205  | 0.404     | 0   | 1    |
| Flexibility                        | 3,072       | 0.136  | 0.343     | 0   | 1    |
| Institutional incoming spillovers  | 3,072       | 1.451  | 0.652     | 0.620 | 3.557 |
| Internal sources                   | 3,072       | 2.358  | 0.129     | 2.054 | 2.643 |
| Public incoming spillovers         | 3,072       | 2.186  | 0.334     | 1.712 | 3.129 |
| Strategic protection               | 3,072       | 0.599  | 0.226     | 0.101 | 1.141 |
| Legal protection                   | 3,072       | 0.488  | 0.179     | 0.136 | 0.778 |
Table A3. Results of the multinomial logit estimation

| Cooperation form | Class 1 | Class 2 | Class 3 | Class 5 |
|------------------|---------|---------|---------|---------|
| (Class 4: subcontracting—ref) | Joint venture | Multi-partnerships | Common research | Contractual research |
| Log R&Dexp | −0.619*** | −0.006 | −0.009 | 0.006 |
| Size | 0.614 | 0.153*** | 0.025 | 0.143** |
| Part group | | | | |
| Domestic | 0.483** | 0.281 | 0.347** | 0.308* |
| Foreign group | 0.698*** | 0.087 | 0.417** | 0.332 |
| Market shares | 1.301* | 0.592 | 0.551 | 0.715 |
| Risk | 0.489** | 0.345 | 0.227 | 0.930*** |
| Role of the firm in the relation | | | | |
| Market oriented | 0.338* | −0.388* | 0.070 | −0.126 |
| Mixed | 0.428* | 0.291 | 0.724*** | 0.918*** |
| Motives | | | | |
| Scale economies | 0.474** | 0.715*** | 0.441** | 0.728*** |
| New markets | −0.355* | 0.249 | 0.153 | 0.762*** |
| Competencies | −0.559*** | 0.111 | −0.345*** | 0.322** |
| Equipment | −0.951*** | −0.532*** | −0.532*** | 0.099 |
| Flexibility | 0.076 | 0.191 | −0.362* | 0.244 |
| Institutional incoming spillovers | 0.044 | −0.321 | 0.284 | 0.239 |
| Internal sources | 0.064 | −0.676 | 1.927*** | 0.154 |
| Public incoming spillovers | −0.248 | 1.621*** | −0.274 | 0.336 |
| Strategic protection | 1.191* | 0.947 | −0.314 | 0.401 |
| Legal protection | −1.701*** | −1.291** | −1.295** | −0.653 |
| Constant | −0.612 | −2.794 | −3.760** | −3.396* |
| Number of observations | 3,072 |
| Wald Chi² (72) (Prob > Chi²) | 414.39 (0.000) |
| Pseudo R² | 0.0569 |

Note: Standard errors are adjusted for 1,626 clusters (firms).
*Significant at 10% level, **5% level, ***1% level.
### Table A4. Wald tests for independent variables

| Variable                        | Chi²    | Df | Prob > Chi² |
|---------------------------------|---------|----|-------------|
| Log R&Dexp                      | 11.291**|    |             |
| Size                            | 9.342*  |    |             |
| Part group                      |         |    |             |
| Domestic                        | 7.300   | 18 |             |
| Foreign group                   | 12.802**| 18 |             |
| Market shares                   | 3.325   |    |             |
| Risk                            | 27.293***| 18|             |
| Role of the firm in the relation|         |    |             |
| Market oriented                 | 16.307***| 18|             |
| Mixed                           | 30.892***| 18|             |
| Motives                         |         |    |             |
| Scale economies                 | 14.686***| 18|             |
| New markets                     | 36.750***| 18|             |
| Competencies                    | 36.665***| 18|             |
| Equipment                       | 42.882***| 18|             |
| Flexibility                     | 11.764** | 18|             |
| Institutional incoming spillovers| 5.800   |    |             |
| Internal sources                | 10.665** | 18|             |
| Public incoming spillovers      | 23.866***| 18|             |
| Strategic protection            | 6.373   |    |             |
| Legal protection                | 8.881*  |    |             |

*Significant at 10% level, **5% level, ***1% level.

### Table A5. Wald test of the Null that respective categories can be collapsed

| Categories tested | Chi²    | Df | Prob > Chi² |
|-------------------|---------|----|-------------|
| 1–2               | 116.320 | 18 | 0.000       |
| 1–3               | 58.213  | 18 | 0.000       |
| 1–4               | 108.065 | 18 | 0.000       |
| 1–5               | 142.443 | 18 | 0.000       |
| 2–3               | 82.123  | 18 | 0.000       |
| 2–4               | 104.194 | 18 | 0.000       |
| 2–5               | 68.205  | 18 | 0.000       |
| 3–4               | 88.159  | 18 | 0.000       |
| 3–5               | 98.403  | 18 | 0.000       |
| 4–5               | 139.718 | 18 | 0.000       |

### Table A6. Hausman tests of IIA assumption

| Omitted | Chi² | Df | Prob > Chi² | Evidence |
|---------|------|----|-------------|----------|
| 1       | 7.564| 57 | 1.000       | For H0   |
| 2       | −1.567| 57 | 1.000       | For H0   |
| 3       | −1.271| 57 | 1.000       | For H0   |
| 5       | 45.806| 57 | 0.856       | For H0   |

*Note: H0: Odds (Outcome-J vs. Outcome-K) are independent of other alternatives.