Available online at www.sciencedirect.com
ScienceDirect
Research Policy 37 (2008) 97–114
research policy
www.elsevier.com/locate/respol

Technological flows and choice of joint ventures in technology alliances

Esteban García-Canal *, Ana Valdés-Llaneza [1], Pablo Sánchez-Lorda [2]

University of Oviedo (Spain), Faculty of Economics Sciences, Avda. Cristo s/n., 33071 Oviedo, Spain

Received 3 May 2006; received in revised form 21 May 2007; accepted 4 June 2007
Available online 29 October 2007

Abstract

This paper analyses the influence of technological flows in the choice of joint ventures as a governance form of technology alliances, using a theoretical framework based on Transaction Costs Economics and the Economics of Intellectual Property Rights. We argue that the formation of a joint venture is only necessary in situations for which technological flows make the monitoring of alliance activities and the distribution of cooperation rents difficult. Our hypotheses have been confirmed using a sample of technology alliances created by companies from the European Union between 1992 and 1999.

Keywords: Technology alliances; Contractual form; Technological flows; Joint ventures

1. Introduction

The R&D boundaries of the firm, i.e. the governance choices in the R&D process, constitute a mainstream topic in the fields of technology and strategic management (Pisano, 1990, 2006; Oxley, 1997; Veugelers and Cassiman, 1999; Arora et al., 2001; Arora and Merges, 2004; Tallman and Phene, 2006). Many papers have studied this issue, whose importance has been rising due to the growing trend to use external sources of technology (von Hippel, 1988; Nooteboom, 1999). In effect, technological change and global competition have forced firms to search for external sources of knowledge through a wide diversity of alliances (Hagedoorn and Osborn, 2002). In fact, firms are also looking for external sources for specific R&D services, even from emerging countries (UNCTAD, 2005). Thus, the R&D process that was once performed in house is now organized through a network of technological alliances in order to reap the benefits of complementary skills and fast product development (Rothaermel and Deeds, 2004; Colombo et al., 2006). Given this proliferation of technological alliances, their effective governance becomes a key factor in designing a technology strategy.

The identity of the main drivers behind the use of joint ventures (henceforth JVs) as a governance form in technology alliances is a puzzling question, still not fully understood despite research carried out by Pisano (1989), Osborn and Baughn (1990), Gulati (1995), Oxley (1997), Colombo (2003), and Sampson (2004). The literature on contractual form in strategic alliances shows that JVs are an appropriate governance form for dealing with complex alliances (García-Canal, 1996; Colombo, 2003) and those entailing high appropriability hazards (Oxley, 1997). By setting up an administrative hierarchy as well as a basis for distributing the rents of the cooperation, JVs can protect their partners from opportunism.

* Corresponding author. Tel.: +34 985 103693; fax: +34 985 236670.
E-mail address: egarcia@uniovi.es (E. García-Canal).
[1] Tel.: +34 985 103914; fax: +34 985 236670.
[2] Tel.: +34 985 104858; fax: +34 985 103708.

0048-7333/$ – see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.respol.2007.06.009

Table 1
Previous empirical evidence of determining factors of the creation of JVs

	Factors	Positive influence	Neutral effect (not significant)	Negative influence
Functional domain of the agreement	R&D	Gulati (1995), Oxley (1997)[b], Oxley (1999), Pisano (1989)[c], Osborn and Baughn (1990), Gulati and Singh (1998)	Colombo (2003)	García-Canal (1996), Pisano et al. (1988)[a], Rialp and Salas (2002)[c], Casciaro (2003)
	Several functional areas	García-Canal (1996), Colombo (2003), Oxley (1997)[b], Oxley (1999), Pisano et al. (1988)[a], Pisano (1989)[c], Rialp and Salas (2002)[c], Oxley and Sampson (2004), Sampson (2004)		
	Production	Casciaro (2003), Pisano et al. (1988)[a], Tallman and Phene (2006)		
	Technology transfer		Pisano et al. (1988)[a]	
	Marketing		Casciaro (2003), Pisano et al. (1988)[a]	Tallman and Phene (2006)
	License			Casciaro (2003), Tallman and Phene (2006)
	Supply		Tallman and Phene (2006)	Casciaro (2003)
Other domains of agreement	Number of partners	García-Canal (1996), Colombo (2003), Croisier (1998)[b], Oxley (1997)[b], Oxley and Sampson (2004), Rialp and Salas (2002)[c]	Gulati (1995), Gulati and Singh (1998), Sampson (2004)	
	Number of products or technologies	Croisier (1998)[b], Oxley (1997)[b], Oxley (1999), Pisano (1989)[c], Sampson (2004)[d]	Oxley and Sampson (2004)	
	Cooperation covers several countries	Croisier (1998)[b]		García-Canal (1996), Oxley (1997)[b]
	Duration	Croisier (1998)[b]		
	Interdependence	Gulati and Singh (1998)		
	Diversification product/market	Rialp and Salas (2002)[c]		
Partners' characteristics	Competitors	Rialp and Salas (2002)[c]	Oxley (1997)[b], Colombo (2003)	Oxley and Sampson (2004)[d]
	International partners	Gulati (1995)		Oxley and Sampson (2004)[d]
	Previous relationships	Colombo (2003)	García-Canal (1996), Oxley (1997)[b], Oxley and Sampson (2004), Sampson (2004)	Gulati (1995), Casciaro (2003)[d] Gulati and Singh (1998)
	Partners' experience in alliance management		Oxley (1997)[b], Colombo (2003), Hagedoorn et al. (2005)	
	Companies' technological diversity	Sampson (2004)[e], Colombo (2003), Hagedoorn et al. (2005)		
	Reputation		Sampson (2004)	
Domain of the alliance	Effectiveness of the intellectual property protection systems			Oxley (1999)
	Cultural distance	Hagedoorn et al. (2005)[d]	Oxley (1999)	
	Industry's technological intensity	Osborn and Baughn (1990)		Hagedoorn and Narula (1996)[a], Hagedoorn et al. (2005)
	Number of potential allies			Pisano (1989)[c]

[a] Bivaried tests.
[b] Tests based on ordered logit model of three categories in which the JVs are the third category.
[c] Minority shareholdings are grouped together with JVs.
[d] Only partial evidence.
[e] Relation in the shape of inverted U.

However, despite the growing complexity of technology alliances (Lerner and Merges, 1998), the percentage of them adopting the JV form is falling dramatically. By analysing data on R&D partnerships formed between 1960 and 1998, Hagedoorn (2002) found that the share of JVs in new R&D partnerships formed each year had fallen from 90% in 1970 to less than 10% in 1998. Although appropriability hazards are very important in technology alliances, their study has not been comprehensively undertaken until recently (Oxley, 1997; Oxley and Sampson, 2004).

This paper tries to shed light on the issue of why technology alliances are organized, or not, through the creation of JVs. For the purposes of this paper we consider two main governance options: JVs and contractual agreements. Building on insights from Transaction Costs Economics (henceforth TCE) (Williamson, 1985, 1996) and recent research on the Economics of Intellectual Property Rights (henceforth EIPR) (Merges, 1999; Lerner and Merges, 1998) we highlight the role of technological flows between partners and also between partners and the alliance as a key factor in the choice of governance form for strategic alliances. We argue that the formation of a JV is only necessary in those situations for which the monitoring of alliance activities and the distribution of cooperation rents are rendered difficult by technological flows. Although the creation of a JV is a complex issue and there are other frameworks for analysing it, our goal in this paper is not to develop a theoretical model that considers all the factors that potentially influence the formation of JVs. Instead, we limit ourselves to analysing to what extent appropriability hazards stemming from technological flows may increase the propensity to form JVs. For this reason, we only use TCE and EIPR literature to develop our theoretical framework, although we will use other theoretical approaches in our empirical analysis in order to introduce control variables in our estimates.

Among the alternative approaches to analysing the formation of JVs, we can outline the following. First, researchers who have tried to apply the principles of the Theory of Social Networks to this issue (Burt, 1982; Granovetter, 1985; Gulati, 1995). Authors taking this approach argue that formation of JVs is not necessary when the alliance is embedded in a long lasting relationship between firms. A second approach is based on the principles of the Organizational Design (Galbraith, 1977; Lawence and Lorch, 1967; Thompson, 1967). The key factor in this case is the ease with which JVs are able to solve coordination problems among partners (Casciaro, 2003; Gulati and Singh, 1998). This last approach is compatible with more recent contributions based on the competence perspective (Nelson and Winter, 1982; Prahalad and Hamel, 1990; Teece et al., 1997). Among them, Colombo's (2003) work stands out. Colombo (2003) contends that the likelihood of creating JVs decreases according to the similarity of their technological specialization, as JVs are seen as a means of transferring tacit know-how.

While all of these approaches show a remarkable complementarity (Gulati and Singh, 1998), Table 1 shows that empirical results have not always confirmed the predictions to which they give rise. However, it is true that for some factors the empirical work carried out has obtained conclusive results. Thus, when the alliance includes several functional areas, several products and technologies or several partners, and is also open-ended in terms of its duration, a clear propensity to create JVs seems to exist (Colombo, 2003; Croisier, 1998; García-Canal, 1996; Oxley, 1997; Oxley, 1999; Oxley and Sampson, 2004; Pisano, 1989; Rialp and Salas, 2002; Sampson, 2004). This is a predictable result from TCE or even from the perspective of Organizational Design, since in such cases coordination and/or motivation problems usually increase. However, in spite of the fact that these problems also increase when collaboration covers several countries, the studies undertaken to date have not obtained conclusive results for this factor (Croisier, 1998; García-Canal, 1996; Oxley, 1997). Moreover, those results relating to certain partners' characteristics are inconclusive. The results relating to the existence of previous cooperative relationships among partners deserve special attention, since according to the Theory of Social Networks these would imply a lower probability of creating JVs, a result which turns out to be conclusive only in Gulati (1995) and Gulati and Singh (1998).

Given these inconclusive results, our empirical work takes these variables into account in order to clarify their influence and to increase the robustness of our results. The Thomson Financial-SDC Platinum database has been used as a source of empirical evidence. We have elaborated a dataset that includes all technology alliances formed between 1992 and 1999 in which at least one European firm has participated. In all, we have included information from 2853 technology alliances.

2. Theoretical framework

2.1. Appropriability hazards in technology alliances

In the field of technology alliances the main source of opportunistic behaviour and governance problems are the so-called *appropriability hazards* (Teece, 1986; Kogut, 1988; Oxley, 1997). These hazards refer to the risk of suffering the consequences of an inadequate use of knowledge and assets contributed to the alliances, or an inadequate distribution of the cooperation rents. Such a risk implies a series of organizational problems in technology alliances, which can be identified as follows:

- *Definition of residual control rights*. Partners must have control and task coordination mechanisms at their disposal that allow the adequate assembly of their contributions – technological knowledge and other resources – in order to achieve the pursued objectives. At the same time, such mechanisms must make it possible for the partners to avoid an inadequate use of the contributed assets.
- *Distribution of cooperation rents according to contributions made*. The most common problems within this block are related to the distribution of the rents from the alliance (financial profits and the ownership of the new technologies generated, amongst others) in accordance with partners' contributions and their performance or the effort made.

Both problems can be overcome through the particular constitution of the alliances' governance form. If the alliance adopts the form of a JV, an administrative hierarchy will be established to assure control rights to supervise the use of the pooled resources. In addition, the ownership structure of the JV establishes a criterion for distributing alliance rents. Setting up this hierarchy, however, has two drawbacks. On the one hand, there are some start-up and operating costs pertaining to the new society, which must be assumed by the partners, and which in some cases may exceed the coordination needs of the alliance (Reuer and Ariño, 2002). On the other hand, the joint ownership of the venture implies that all partners hold a stake in the residual value of the cooperative project without specifying *ex ante* performance requirements (Kogut, 1988; Contractor and Ra, 1998). For this reason, the JVs will be a more attractive option for partners when it is more difficult to know beforehand the use to be given to the contributed assets. In these cases, protection from misappropriation risks by means of contractual agreements is more difficult, because it is not easy to determine the assets' remuneration, or to delimit the conditions under which they must be used. In the remaining cases, relying exclusively on contractual agreements – the alternative to forming a JV, labelled generically contractual agreements – will constitute the best option, because partners can protect themselves from the risks of opportunism by means of contracts, and besides, the two disadvantages derived from the establishment of the administrative hierarchy we have just mentioned are avoided. Recent contributions in the field of the EIPR (Lerner and Merges, 1998; Merges, 1999; Arora and Merges, 2004) highlight the critical role played by Intellectual Property Rights in assuring the effectiveness of contractual agreements. In fact, empirical research shows that JVs are more frequently used in countries in which the effectiveness of the Intellectual Property Rights System is negligible (Oxley, 1999; Hagedoorn et al., 2005).

2.2. Technological flows and contractual form

The starting point for our framework is the realization that not all technological alliances are equal, as appropriabity hazards are different depending on the technologies being transferred to the alliance, and depending also on the degree to which new technologies are generated. These two dimensions of technology alliances condition both the problems of control, and that of rent distribution, discussed above. There are three possible situations according to the transfer of existing technologies: none or zero transferral, unilateral transferral or bilateral transferral. In addition, there are some alliances which may have as their aim the generation of new technologies – in such cases the partners will undertake some kind of cooperative R&D activity – while others do not. Combining these two dimensions, it is possible to identify five types of alliances depending on the technological flows entailed by each[3] (for each type we describe an example extracted from Thomson Financial SDC) as follows:

I. *Unilateral transfer of an existing technology without undertaking R&D activities*. An example of this kind of agreement is the one signed in 1985 by Oki Electric and Thomson Semiconductor under which the former transferred to the latter the manufacturing technology for a very large scale integration (VLSI) memory chips.

II. *Cross-transfer of existing technologies without undertaking R&D activities*. An example of this case is the Eurokera alliance, formed in 1994 by Corning and The Compagnie de Saint-Gobain of Paris, to manufacture and sell flat glass-ceramic cook tops.

[3] Note that we are only showing five types of technological flows in technological alliances because an alliance without undertaking R&D activities and without the transfer of an existing technology is not a technology alliance.

Corning provided product technology, while process technology was provided by Saint-Gobain.

III. *R&D based on already existing technology at the moment of the creation of the alliance*. An example is the alliance signed in 1993 by the biotechnology company Applied Microbiology and the pharmaceutical SmithKline Beecham. Both firms agreed to jointly develop applications for oral hygiene products based on the AMBICIN-N anti-microbial agent previously developed by Applied Microbiology.

IV. *R&D based on a combination of technologies already existing at the moment of the creation of the alliance*. An example for this category is the alliance signed in 1994 by 3Dlabs Inc and RenderMorphics. At the time the British company RenderMorphics had developed an application programming interface and the American company 3D Labs had developed the graphic accelerator GLINT. The aim of the alliance was to develop an integrated solution combining both technologies for games, simulators and virtual reality software.

V. *R&D without antecedents*. An example is the agreement signed in 1992 by Philips Electronics and Motorola, to create the Motorola Philips Design Centre in Eindhoven in order to design integrated circuits for multimedia products.

Table 2 shows these five types of alliances, and also summarizes the main appropriability hazards which may arise regarding the control of alliance activities and in relation to the distribution of rents in each alliance, based on the arguments outlined below. Next, we will analyse both organizational problems for each of these five cases. We will also make predictions regarding the choice of contractual form.

2.2.1. Unilateral transfer of an existing technology without undertaking R&D activities

In this case one company hands over use of the already existing technology to another, or to the alliance, under specific terms of use. In this context, if the protection mechanisms for the intellectual property function adequately, the rights of the owner of the technology can be protected by means of a contract specifying authorized uses of partners' resources and their compensation for these uses (Pisano, 1989; Merges, 1999). Participation in a JV as a result of the simple contribution of technology would not be justified as a safeguard of interests. In fact, this circumstance could discourage partners if the company's only contribution were technology, since they would have to share with it the residual value of the JV (Contractor and Ra, 1998). Given that this is the simplest case, we consider it as a base reference in our analysis of the likelihood of creating a JV in the other cases.

2.2.2. Cross-transfer of existing technologies without undertaking R&D activities

In this situation, the alliance is created to exploit opportunities associated with the combination of two related technologies belonging to different companies. The companies hand over their own technologies to each other or to the alliance for their posterior combination. Thus the alliance is created so that the technologies can be combined and it usually has, in this respect, a greater strategic component than the previous one (Teece, 1992). There is a problem in these alliances, which justifies the creation of a JV: lack of certainty regarding the rents obtainable from the combination of technologies. Moreover, as Somaya and Teece (2001) point out, the contribution of a technology to a product of the combination of several technologies is not easy to determine, since each technology is an input that is difficult to dissociate from the final product. According to Pisano (1989) and Oxley (1997), equity ownership should be a solution in contexts which are, like this one, surrounded by uncertainty, not only because it defines residual control rights, but also because it aligns incentives. As a consequence, JVs would in this context have the advantage of facilitating the distribution of rents through joint participation in the equity of the venture (Kogut, 1988). Having a stake

Table 2
Influences of technological flows on misappropriation risks in alliances

Technology transfer	Generation of new technologies	
	Yes	No
Unilateral	Easy control of alliance activities Easy distribution of alliance rents	Easy control of alliance activities Easy distribution of alliance rents
Bilateral	Easy control of alliances activities Easy distribution of alliance rents	Easy control of alliance activities Difficult distribution of alliance rents
Without antecedents	Difficult control of alliance activities Easy distribution of alliance rents	Not applicable

in the residual value of the JV is an inducement to make the adaptation required by the combination of technologies to work effectively (Somaya and Teece, 2001). This combination of technological resources, on the other hand, may generate what Hamel and Prahalad (1994) call "higher order resources", which can generate a completely new market. In this context, the JVs would allow the partners to guarantee themselves a continuous presence in that new market, by reason of their shareholding (Contractor and Ra, 1998). For these reasons, we state that

Hypothesis 1. *In the technology alliances implying a bilateral transfer of existing technology without undertaking R&D activities, JVs will be preferred to contractual agreements.*

2.2.3. R&D based on an already existing technology of one of the partners

In this case, research and development activities are carried out starting from one of the partner's technological resources. Although there is uncertainty about the result of cooperative activities, partners can specify the conditions under which they will share the rights over technologies generated in the alliance by means of contracts (Lerner and Merges, 1998; Merges, 1999). In fact, insofar as the alliance's main performance is associated with output as a result of technological activity, partners can carry out a distribution of intellectual property according to their needs. Frequent solutions in this respect are the distribution of this output under different patents for each partner or the joint ownership of them (Hagedoorn et al., 2003). In fact, joint ownership (on the part of several companies) of intellectual property rights is a phenomenon which has grown constantly in the last few years, as shown by Hagedoorn (2003), related to R&D alliances.[4] On the other hand, as the starting point is an already existing technology, there is less uncertainty about the direction activities must follow (Pisano, 1989). For this reason, partners are able to protect themselves from an unwanted use of their technology, protecting their rights over it through patent and/or trade secrets. In these circumstances, the creation of JVs is not necessary to protect partners' interests. In accordance with these arguments we state that

Hypothesis 2. *In technology alliances in which partners undertake R&D activities starting from an existing technology owned by one of them, contractual agreements will be preferred to the creation of JVs.*

2.2.4. R&D based on a combination of already existing technologies

In this context, research and development activities are carried out starting from two or more technologies belonging to different partners. Although in this case there is uncertainty about the rents which can be generated from cooperation, their distribution can be carried out by means of contracts, since these can specify conditions allowing partners access to ownership (or joint ownership) of a patent (Lerner and Merges, 1998; Merges, 1999). According to Barzel's approach (1982, 1989), joint ownership of new technologies may minimize problems related to the value assessment of resources contributed. This circumstance allows partners to participate in the performance generated by their resources (the new technology) without having to confront problems associated with an assessment of their value. On the other hand, although it is possible that the existence of technological flows on the part of both partners may create greater coordination problems, partners can define the conditions under which their technologies can be used, thus reducing the moral hazard involved (Pisano, 1989). We therefore face a similar case to the previous one, and so we see that the creation of JVs does not present advantages over an exclusive reliance on contracts. In consonance with this reasoning, we formulate:

Hypothesis 3. *In technology alliances in which partners undertake R&D activities starting from the combination of existing technologies, contractual agreements will be preferred to the creation of JVs.*

2.2.5. R&D without antecedents

In this case, partners' technologies do not constitute a starting point for research and development activities. The problem confronted in this situation is uncertainty regarding partners' future behaviour, which is maximized in this case. This is due to the fact that the likelihood of specifying *ex ante* patterns of behaviour and performance requirements is minimum, since there are no antecedents partners can use to plan their activities. According to Walker and Weber (1984) and Williamson (1985) this uncertainty increases the chances of opportunistic behaviour. Specifically, in this context there is the risk that some of the partners would take advantage of such a difficulty to divert R&D activities towards their own interests, to the detriment of other partners (Borys

[4] In order to support our theoretical approach in relation to a substitution relationship among JVs and joint patents, it must be pointed out that this increase in the joint ownership of patents has coincided with a reduction in the rate of formation of JVs in the R&D alliances (Hagedoorn and Osborn, 2002).

and Jemison, 1989). On the other hand, technological knowledge contributed by partners is not integrated into a technology and, therefore, it is difficult to specify in a contract their authorized uses. Such technological knowledge is, consequently, less protected than in the remaining cases (Merges, 1999) Once again, joint ownership should be a solution to this uncertainty problem as it defines residual control rights which can overcome appropriability hazards associated with uncertainty (Pisano, 1989; Oxley, 1997). Thus, under these circumstances, the JVs allow partners to assure residual control rights over the activities of the agreement and prevent unwanted uses of contributed knowledge. According to these arguments we put forward:

Hypothesis 4. *In technology alliances in which partners undertake R&D activities without having their own existing technologies as a starting point, JVs will be preferred to contractual agreements.*

3. Methodology

3.1. Empirical setting

As a source of empirical evidence we have used the SDC Platinum database. This dataset, distributed by Thomson Financial, collects, among others, news related to mergers and acquisitions, corporate governance and restructuring, together with the formation of JVs and strategic alliances. Specifically, in the sub-base *Joint Ventures & Strategic Alliances*, SDC offers a systematic analysis from 1988 of the formation of all kinds of alliances[5] by companies all over the world.

The sample of alliances used are those created up until 1999 by companies from the fifteen countries then making up the European Union, which have been identified through the Joint Ventures and Strategic Alliances base included in Thomson Financial SDC-Platinum. We have selected the alliances of technological content formed between 1992 and 1999 from this dataset. We defined an alliance with technological content as involving either the transfer of existing technological knowledge and/or joint research and development. The main reason for focussing on EU countries was the aim to find a balance between the need to have a large dataset including alliances formed by firms from different countries and, on the other hand, the necessity of being able to effectively track previous relationships between partners.[6] As previously mentioned, the existence of previous cooperative relationships between partners is a factor already included in previous research as an independent or control variable. According to Narula and Hagedoorn (1999), having only EU firms does not introduce a significant bias, as "the propensity to use equity agreements is associated with industry-specific differences, rather than country-specific differences."

We have considered all the alliances created for carrying out R&D activities and/or for the transfer of technology or technologies already in existence at the moment the alliance is created as alliances of technological content. The sample finally used comprises 2853 technology alliances. Of them, 1683 are alliances to carry out cooperative R&D activities (which may or may not include the transfer of already existing technologies as part of the agreement[7]) and the rest include the transfer of already existing technologies without entering into cooperative R&D. Within this last block, 720 alliances imply a unilateral technology transfer of one partner to others or to another, or to the alliance itself, and 450 involve a crossed technology transfer from several partners to each other or to the alliance itself.

Table 3 shows the distribution of agreements according to the number of partners involved. More than 96% of the alliances comprise two or three partners, which is consistent with previous studies (Morris and Hergert, 1987). In relation with the geographical area of the alliance activities, Table 4 shows a high number of alliances involving activities in more than one area (33.6 %), while the European Union is the preferred target location for alliances aimed at one single area (more than 31% of the cases) followed by the USA (20%).

3.2. Dependent variable and method of analysis

As dependent variable we used a dummy variable taking the value one in those alliances in which a JV is

[5] The alliances are defined as "Agreements where two or more entities have combined resources to form a new, mutually advantageous business arrangement to achieve predetermined objectives. All types of alliances are covered including: JVs, Strategic alliances, Licensing and exclusive licensing agreements, Research and development agreements, Manufacturing agreements, Marketing agreements, Supply agreements" (on-line bluesheet describing Thomson Financial Joint Ventures and Strategic Alliances database available at http://library.dialog.com/bluesheets/pdf/bl0554.pdf). It should be noted that although SDC also includes alliances formed before 1988, the approach taken for the analysis of data pertaining to this period is less exhaustive.

[6] As shown below, in order to calculate these previous relations, we have carried out a screening of the SDC dataset from 1982 to the moment when each alliance is formed looking for each pair of firms.

[7] See Table 7 in Section 4 with the distribution of alliances of our sample among the five categories of technological flows.

Table 3
Number of alliances according to number of partners involved

Number of Partners	Number of alliances	%
2	2500	87.63
3	253	8.87
4	50	1.75
5	18	0.63
6	17	0.60
7	6	0.21
8	3	0.11
9	2	0.07
12	1	0.04
15	1	0.04
16	1	0.04
17	1	0.04
Total	2853	100

created, and zero in contractual agreements. Since this dependent variable is binary, in order to test the hypotheses previously formulated several binomial logit models with robust standard errors were estimated in which the likelihood of an alliance adopting the contractual form of JV is explained by the independent variables defined below. The general specification of a logit model is the following (Aldrich and Nelson, 1984):

$$\log\left[\frac{P(Y_i=1)}{(1-P(Y_i=1))}\right]=\alpha+\beta' X_i$$

where $P(Y_i=1)$ is the probability of an alliance i adopting the contractual form of JV, α is the independent term and β the vector of coefficients associated with the independent and control variables (defined below). In the estimates, the coefficients obtained for independent and control variables indicate the impact (positive or negative) of an increase in such variables on the probability of the contractual form of the alliance being JV.

Table 4
Number of alliances in each geographical area

Area	Number of alliances	%
European Union	886	31.1
Europe (non-EU)	48	1.7
Latinamerica	12	0.4
OCDE	142	5.0
Other	248	8.7
USA	580	20.3
Unknown	7	0.2
Supranational	930	32.6
Total	2853	100

3.3. Independent variables

The independent variables are related to the technological flows of the alliance. In order to create these variables we have taken into account three flags included in the SDC database:[8] (1) "*Technology Transfer flag*" is codified as "*Yes*" if the alliance implies the transmission of an existing technology from one partner to another or to the alliance; (2) "*Cross Technology Transfer flag*" is codified as "*Yes*" if the alliance implies the cross-transfer of existing technologies between two or more partners or between these and the alliance; (3) "*R&D agreement flag*" is codified as "*Yes*" if the alliance includes the undertaking of R&D activities. With these flags, we built the following independent variables:

Unilateral transfer of existing technology: dummy variable valued 1 when the alliance implies the transmission of an existing technology from one partner to another or to the alliance and, moreover, it does not include the undertaking of R&D activities, and is valued 0 otherwise ("*Technology Transfer flag*" is valued "*Yes*", and "*R&D agreement flag"* and "*Cross Technology Transfer Flag*" are valued "*No*").

Cross-transfer of existing technologies: dummy variable valued 1 when the alliance implies the cross-transfer of existing technologies between two or more partners or between these and the alliance and when it does not include the undertaking of R&D activities, valued 0 otherwise ("*Cross Technology Transfer flag*" is valued "*Yes"*, and "*R&D agreement flag"* is valued "*No*").

R&D based on existing technology: dummy variable valued 1 when the alliance includes the undertaking of R&D activities and, moreover, involves transmission of existing technology from one partner to the alliance, and valued 0 otherwise ("*Technology Transfer flag*", as well as "*R&D agreement flag"* are valued "*Yes*" and "*Cross Technology Transfer Flag*" is valued "*No*").

R&D based on the combination of existing technologies: dummy variable valued 1 when the alliance includes the undertaking of R&D activities and also involves the crossed transmission of technologies on

[8] According to Thomson Financial SDC, the exact definition of these flags are as follows: (1) Alliance Technology Transfer Flag (Y/N): Yes/No flag set to 'Yes' if one participant transfers technology to another participant or to the alliance; (2) Alliance Cross Technology Transfer Flag (Y/N): Yes/No flag set to 'Yes' if more than one participant transfers technology to another participant or to the alliance; (3) Alliance Research & Development Agreement Flag (Y/N): Yes/No flag set to 'Yes' if the alliance is a research and development agreement.

the part of partners, and 0 otherwise ("*Cross Technology Transfer flag*", as well as "*R&D agreement flag"* are valued "*Yes"*).

R&D without antecedents: dummy variable valued 1 when the alliance includes the undertaking of R&D activities without using previous technology on the part of partners as the starting point, and 0 valued otherwise ("*Technology Transfer flag*", as well as "*Cross Technology Transfer flag*" are valued "*No*", and "*R&D agreement flag"* is valued "*Yes*").

As one of these variables must be excluded from estimates, we have opted for not including that associated with the unilateral transfer of existing technology, as it is the simplest technological flow and reference category. This variable will then be the one acting as a reference for the others' behaviour, as explained in Section 4. The most frequent agreement are alliances involving R&D activities without using previous technology, followed by operations implying the transmission of an existing technology from one partner to another or to the alliance and without the undertaking of R&D activities (see Table 7 in Section 4).

3.4. Control variables

Apart from including the variables mentioned above, several variables already used in previous literature have been included with a double purpose. On the one hand, to control for other factors which could contaminate the effect of technological flows. On the other hand, to provide new empirical evidence which could shed some light on the contradictory results obtained in previous literature. Specifically, we have included the following control variables:

Multiple partners: Dummy variable valued 1 in those alliances integrated by more than two partners, and valued 0 otherwise. The coefficient associated with this variable is expected to have a positive sign due to the problems of incentives originated by having more than two partners. We included this variable in this study as empirical evidence has consistently shown that equity JVs are more frequently used to organize multilateral alliances (García-Canal, 1996; Oxley, 1997; Sampson, 2004). The data on the number of partners involved in each agreement were obtained directly from SDC—field entitled "Number of Participants in Alliance".

Open length: Building on TCE established arguments regarding the frequency of the transaction, Croisier (1998) shows that the propensity to use JVs is greater, the longer the expected duration of the agreement. For this reason we include this dummy variable valued 1 in those alliances, which according to the information provided by SDC – which has a specific flag called "Open Length" for this matter – have an indefinite duration, and valued 0 otherwise. The coefficient associated with this variable is expected to have a positive sign due to the greater uncertainty surrounding the agreement and, as a result, to give rise to greater difficulty in writing contractual agreements protecting partners against several contingencies.

Patent effectiveness: The effectiveness of the system of patents of the country or countries where alliance activities are carried out can influence the propensity to create JVs. In fact, one resource for protecting the technological knowledge generated in alliances is to patent the technology. However, partners have to take into account the fact that the systems for protecting intellectual property rights are not the same in all countries. When the systems for protecting intellectual property are strong, JVs will not be necessary to guarantee the participation of partners in the output of R&D alliances (Oxley, 1999; Hagedoorn et al., 2005). This variable has been elaborated using Ginarte and Park's methodology (1997). These authors elaborated an index based on an examination of five categories of patent law: extent of coverage, membership in international patent agreements, provisions for loss of protection, enforcement mechanisms and duration of protection. In the above-mentioned paper, they develop the methodology and calculate indexes for 110 countries for the years 1980, 1985 and 1990. Due to the methodology used, this index can only be calculated every five years. As our sample covers the years 1992–1999, we have used the values of this index for 1995, which appear in Park (1999). The index fluctuates from 0 to 5, increasing with greater protection and varying between 0 for Ethiopia, Mozambique, Papua New Guinea and Burma and 4.86 for the United States. When the alliance's activities took place in several countries, the arithmetic mean of the indexes for each country was calculated. The coefficient associated with this variable is expected to be negative, so that the greater the effectiveness of the patent system, the lower the need to create JVs to protect the partners' rights over their technological knowledge.

We also included the technological intensity of the industry with the aim of providing new empirical evidence that could shed some light on unclear results obtained in previous literature (Osborn and Baughn, 1990; Hagedoorn and Narula, 1996; Hagedoorn et al., 2005). This technological intensity has been calculated from the OECD classifications for industry (2001) and services (1999). In this way, we have elaborated the dummy variables *High intensity*, *Medium–high intensity* and *Medium–low intensity*, valued 1 for those alliances in which the activity of the agreement is developed in high, medium–high or medium–low technologically intensive industries respectively, and valued 0 otherwise. We also elaborated the variables *Knowledge-intensive services*, a dummy variable valued 1 for those alliances in which the activity of the agreement is developed in service industries requiring a large amount of specialized knowledge and valued 0 otherwise; and *Other services*, dummy variable valued 1 for those alliances in which the activity of the agreement is developed in service industries not included in the previous dummy variable, and valued 0 otherwise.

The low technological intensity industries, together with the mining, construction and agricultural ones act as reference for these variables, for which there is no conclusive empirical evidence in the literature; although greater appropriability hazards could be expected in high technological intensity industries due to the greater strategic value of the technological knowledge.

We also included a dummy variable (*Multiple functions*), valued 1 when the alliance entails, in addition to the technological content, supply, production and/or marketing activities as well, and valued 0 in remaining cases. García-Canal (1996) and Oxley (1997) found that alliances covering several functions were more complex and had a higher propensity to adopt the JVs form. This variable was built using information from the specific flags included in SDC specifying respectively whether the alliance involved supply, manufacturing or marketing activities.

Finally we included the following control variables:

License: Dummy variable valued 1 for those alliances whose formalization included a license agreement, and valued 0 otherwise. This variable was built by observation of the "Licensing Agreement Flag" included in SDC.

Several countries: In spite of the fact that coordination and/or motivation problems increase when collaboration covers several countries, studies have not obtained conclusive results for this factor (Croisier, 1998; García-Canal, 1996; Oxley, 1997). We include a dummy variable valued 1 for those alliances whose activities take place in several countries, and valued 0 otherwise. This variable has been calculated directly from the information provided by SDC, which includes a specific flag for this variable—"Nation of Alliance" field.

Cultural distance: This variable may influence in the use of JVs because of an increase in coordination difficulties among partners. This variable is an index measuring differences among the national cultures of the countries that according to the information provided by SDC, alliance partners come from. In calculating it we have followed the methodology proposed by Kogut and Singh (1988), using the measures of the four dimensions proposed by Hofstede (2001)[9]. Specifically, the following index was calculated:

$$\text{Cultural distance}_{ij} = \frac{1}{4}\sum_{k=1}^{4}\frac{(\mathrm{D}_{ik}-\mathrm{D}_{jk})^2}{\mathrm{V}_k}$$

where Cultural distance$_{ij}$ is a measure of cultural distance existing between countries i and j. D_{ik} and D_{jk} are the values taken by the dimension k in countries i and j, respectively. V_k is the variance of the dimension k. For multiparty alliances we have followed Kim and Park's procedure (2002): First, we calculated Kogut and Singh's (1988) index for each pair of partners and, afterwards, we calculated the mean among these indexes.

Direct competition: Dummy variable valued 1 for those alliances in which at least two companies which are direct competitors participate, and valued 0 otherwise. We regard those companies classified by SDC in the same main-SIC industry at the three digits level as competitors. We have included this variable because empirical evidence is not clear regarding the influence of this factor (Oxley, 1997; Rialp and Salas, 2002; Colombo, 2003; Oxley and Sampson, 2004).

Previous relationships: Total Number of all kinds of strategic alliances (JVs and contractual agreements) previously created among partners of the alliance under analysis. In order to construct this variable we carried out a screening of the SDC dataset from 1982 to the moment at which each alliance is formed. This variable has only been calculated for the alliances between two partners, given the difficulty of interpreting it for any more. Besides, it is in alliances of only two partners where this variable exerts a stronger influence (García-Canal et al., 2003). The results of previous studies have not been conclusive for this variable, either (Gulati, 1995; Gulati and Singh, 1998; Casciaro, 2003; Colombo, 2003; Sampson, 2004; amongst others).

[9] In this work Hofstede stated four dimensions to characterize a country's culture (power distance, uncertainty avoidance, masculinity/feminity, and individualism) and presented estimations of their measures according to a far-reaching empirical study carried out in the 1970s, whose first edition was published in 1980. For certain countries not included in his initial study, we have used the measures proposed by Hofstede (2001) in the second edition of his study.

Table 5
Descriptive statistic and correlation matrix

		Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Joint venture	0.327	0.469	1																		
2	Cross-transfer of existing technology	0.158	0.365	0.355	1																	
3	R&D based on existing tech.	0.119	0.324	−0.171	−0.159	1																
4	R&D based on the combination of existing technologies	0.192	0.394	−0.064	−0.211	−0.180	1															
5	R&D without antecedents	0.278	0.448	0.059	−0.269	−0.229	−0.303	1														
6	Multiple partners	0.124	0.329	0.117	0.118	−0.076	0.041	0.004	1													
7	Open length	0.947	0.223	0.074	0.076	−0.034	0.039	−0.067	0.012	1												
8	Patent effectiveness	3.957	0.835	−0.407	−0.284	0.110	0.099	0.068	−0.074	−0.034	1											
9	High intensity	0.390	0.488	−0.089	−0.079	0.162	0.092	−0.083	−0.023	0.005	0.091	1										
10	Medium–high intensity	0.140	0.347	0.167	0.064	−0.102	−0.046	0.027	−0.017	0.027	−0.161	−0.323	1									
11	Medium-–low intensity	0.030	0.171	0.096	0.098	−0.046	−0.024	−0.018	−0.004	0.014	−0.088	−0.141	−0.071	1								
12	Knowledge-intensive services	0.314	0.464	−0.059	−0.019	−0.031	0.016	0.080	0.064	−0.043	0.090	−0.542	−0.274	−0.120	1							
13	Other services	0.093	0.290	−0.044	0.028	−0.043	−0.091	−0.050	−0.047	0.021	−0.006	−0.255	−0.129	−0.056	−0.217	1						
14	License	0.283	0.451	−0.385	−0.202	0.178	−0.235	−0.211	−0.104	−0.016	0.189	0.098	−0.050	−0.047	−0.029	−0.010	1					
15	Multiple functions	0.140	0.347	0.072	0.003	−0.002	−0.027	−0.034	−0.060	0.027	−0.088	0.065	0.158	0.071	−0.192	−0.041	0.036	1				
16	Several countries	0.395	0.489	−0.225	−0.106	0.036	0.194	−0.065	−0.023	0.001	0.103	0.061	−0.017	0.013	−0.067	0.049	−0.051	0.046	1			
17	Cultural distance	1.175	1.227	0.157	0.089	−0.051	−0.057	−0.061	0.004	0.048	−0.323	0.009	0.131	0.056	−0.121	0.004	−0.065	0.036	0.032	1		
18	Direct competition	0.333	0.471	−0.040	−0.006	0.042	−0.016	−0.001	0.236	−0.010	−0.014	0.072	−0.054	−0.025	−0.008	−0.007	0.039	−0.019	0.012	0.020	1	
19	Previous relationships	0.291	1.300	0.034	0.079	−0.024	0.016	−0.014		−0.007	0.011	0.042	0.019	0.057	−0.043	−0.040	−0.049	0.011	0.058	0.038	0.027	1

Table 5 shows correlations between independent and control variables. In general, there are no high correlations.

4. Empirical results and discussion

Table 6 presents estimates of the logit models built with all the independent and control variables. Specifically, the table shows the value of the coefficients, their standard error and an indication of their significance level for each model. The first column only includes independent variables. Columns (1 and 2) present only control variables corresponding to the two alternative models that can be built with the variables Multiple partners and the Previous relationship variable (calculated only for dyadic alliances). Model (3) only includes independent variables and, finally, Models (4 and 5) show the estimates with independent variables and control variables included in models (1 and 2) respectively. In general, we can observe that the models offer statistically significant estimates with Chi-square values that correspond to significance levels lower than 0.00001 in all cases. Besides, they allow us to classify the various observations satisfactorily in percentages higher than 74%.

As we introduce four of the five dummy variables associated with technological flows in the estimates, estimated coefficients for these variables measure the degree to which the impact of this variable on the probability of forming JVs is significantly different (higher or lower) than that of the omitted variable (Kennedy, 1998). Thus we expect only a positive and significant sign only for the variables Cross-transfer of existing technologies and R&D without antecedents, in which we expect a higher propensity to form JVs. In the remaining variables we expect a non-significant or negative coefficient, reflecting the same or lower propensity to form JVs than in our reference option: the unilateral transfer of existing technology.

Specifically, as predicted by Hypothesis 1, the likelihood of creating JVs is the highest in alliances aimed only at combining already existing technologies without undertaking R&D activities, as the magnitude of the positive and significant coefficient of the variable Cross-transfer of existing technologies indicates.

Hypothesis 2 is also confirmed. In alliances aimed at performing R&D activities using existing technology belonging to one of the partners as a starting point, we observe a significant negative coefficient in all models (see variable R&D based on existing technology). This means that in these alliances there exists a propensity to form JVs even lower than that observed in the reference case: the existing technology unilateral transfer. According to our results, the lowest propensity to form JVs exists in these alliances.

Hypothesis 3 appears at first sight to be rejected, as the R&D based on combination of existing technologies variable shows a positive and significant coefficient in model 3. However, this result is not robust. When the other control variables are included in the equation, we observe a non-significant coefficient in those alliances aimed at performing R&D activities based on the combination of existing technologies from partners (see models 4 and 5). Thus, these alliances have a propensity to form JVs not significantly different to that of the reference case: that of the unilateral transfer of existing technology, confirming our hypothesis. However, the propensity to form JVs in this case is higher than in alliances aimed at performing R&D activities using existing technology owned by one of the partners as a starting point. Having two or more technologies as a starting point thus increases the complexity of the alliance.

Finally, Hypothesis 4 is also confirmed. In those alliances in which R&D activities are carried out without taking the partners' already existing technologies as a starting point, there is a propensity to form JVs higher than in the reference case, as shown by the results of the R&D without antecedents variable in all models.

A simple cross-tabulation can also show how our hypotheses are confirmed. Table 7 includes a cross-tabulation of the dependent dummy variable in our models with a categorical variable that includes our typology of technological flows. The table shows the result of the Chi-square global significance test, as well as Haberman (1978) adjusted standardized residuals. Since one of the variables has more than two categories, the Chi-square presents some limitations in terms of summarizing all the information included in the contingency tables, in particular if we want to analyse the impact of certain categories of an independent variable on some other categories of the dependent one. Adjusted standardized residuals, which follow a quasi-normal distribution, allow us to identify those pairs of categories where the differences between observed and expected (according to the distribution of the category in the whole sample) frequencies are significant. Upon analysing the results of this table, we see that only Cross-transfer of existing technologies and R&D without antecedents have a higher than expected frequency for JVs (Adjusted standardized residuals are positive and significant for the category JVs), confirming hypotheses one and four.

Table 6
Estimates of logit models proposed

Variables	Hypotheses	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Constant		3.090 (6.36)***	3.071 (5.80)***	−1.466 (15.35)***	2.394 (4.60)***	2.351 (4.11)***
Cross-transfer of existing technologies	H1 (+)			2.367 (16.76)***	1.324 (6.35)***	1.396 (6.22)***
R&D based on existing technology	H2 (− or n.s.)			−0.640 (3.22)**	−0.558 (2.18)*	−0.593 (2.21)*
R&D based on the combination exist. tec.	H3 (− or n.s.)			0.444 (3.27)**	−0.005 (0.02)	−0.013 (0.06)
R&D without antecedents	H4 (+)			0.941 (7.81)***	0.383 (2.01)*	0.391 (1.95)†
Multiple partners		0.552 (3.63)***			0.428 (2.66)**	
Open length		0.982 (3.48)**	0.944 (3.06)**		0.822 (2.80)**	0.782 (2.44)*
Patent effectiveness		−0.980 (11.60)***	−0.964 (10.83)***		−0.885 (10.28)***	−0.868 (9.52)***
High intensity		−0.162 (0.58)	−0.171 (0.57)		−0.031 (0.11)	−0.023 (0.08)
Medium–high intensity		0.470 (1.58)	0.397 (1.24)		0.467 (1.55)	0.397 (1.24)
Medium–low intensity		0.616 (1.54)	0.659 (1.56)		0.575 (1.37)	0.696 (1.58)
Knowledge-intensive services		−0.375 (1.32)	−0.430 (1.40)		−0.296 (1.02)	−0.338 (1.10)
Other services		−0.425 (1.36)	−0.347 (1.05)		−0.391 (1.21)	−0.316 (0.93)
License		−3.182 (14.04)***	−3.121 (13.55)***		−2.820 (11.41)***	−2.765 (10.93)***
Multiple functions		0.559 (3.45)**	0.563 (3.38)**		0.575 (3.42)**	0.581 (3.35)**
Several countries		−1.333 (11.65)***	−1.325 (10.72)***		−1.225 (10.21)***	−1.222 (9.39)***
Cultural distance		0.077 (1.77)†	0.076 (1.67)†		0.095 (2.10)*	0.097 (2.07)*
Direct competition		−0.240 (2.06)*	−0.284 (2.20)*		−0.214 (1.77)†	−0.229 (1.71)†
Previous relationships			0.061 (1.86)†			0.028 (0.79)
Number of observations		2577	2262	2853	2577	2262
Log likelihood		−1105.28	−958.62	−1575.56	−1059.65	−916.19
Percentage of cases correctly classified		79.6	79.6	74.0	80.6	80.8

Z-scores shown in parentheses beneath regression coefficients.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
† $p < 0.1$.

Table 7
Cross-tabulation of contractual form and technological flows[a]

	Contractual agreement	Joint venture	Total
Unilateral transfer of existing technology	585 (9.2***)	135 (−9.2***)	720
Cross-transfer of existing technologies	130 (−18.9***)	320 (18.9***)	450
R&D based on existing technology	304 (9.2***)	37 (−9.2***)	341
R&D based on the combination of existing technologies	403 (3.4***)	145 (−3.4***)	548
R&D without antecedents	499 (−3.2***)	295 (3.2***)	794
Total	1921	932	2853
Chi-square	456.419 (4 d.f.) ($p < 0.0001$)		

[a] Each cell includes the frequency of alliances in each case and Haberman (1978) adjusted standardized residuals (in parenthesis).
*** $p < 0.001$.

The remaining categories have a lower than expected observed frequency (Adjusted standardized residuals are negative and significant for the category of JVs), confirming hypotheses two and three as well as the prediction for the reference category: unilateral transfer of existing technology alliances.[10]

To sum up, our results show that an important key factor in the decision of whether or not to use JVs is the existence of property rights previously recognized by partners with reference to technological knowledge contributed by them to alliances. For this reason, the propensity to use JVs in alliances involving collaborative R&D without antecedents differs from the propensity to use this organizational formula in alliances displaying such antecedents. In fact, these antecedents constitute a base to specify property rights over the technological knowledge contributed. Likewise, at this point we must point out the negative result of the variable license, which shows that when a license agreement coexists in an alliance (which necessarily implies the existence of previously differentiated technological knowledge) there is a lesser propensity to create JVs. The second key factor is uncertainty about the rents derived from the combination of assets, which explains the greater propensity to use JVs in alliances of existing cross-technology transfer.

Upon analysing the results of the control variables, we find results that help to clarify the real determinants of the formation of JVs in strategic alliances once all relevant factors are included in the models.

With regard to the number of partners, our results regarding the Multiple partners variable confirm prevailing empirical evidence about the greater propensity to create JVs in alliances of more than two partners. We also carried out estimates – not shown in the paper, but available upon request – with the continuous specification of the Multiple partners variable, which also presented a significant positive effect, although this model presents slightly lower global significance and predictive capacity levels. This result confirms that the most important shift in the influence of the number of partners happens when raising their number from two to three. The multiple functions variable also increases the probability of using the JV form. The results of these two variables confirm that complex alliances tend to adopt the JV form (García-Canal, 1996; Oxley, 1997; Colombo, 2003).

Previous literature (see Table 1) presented contradictory empirical evidence about the influence of the geographical domain of cooperation; specifically the fact that cooperation covers several countries. Our results regarding the Several countries variable confirm those obtained in a previous study (García-Canal, 1996), showing that in those cooperations whose domain exceeded one country there was a lower propensity to create JVs. The explanation of this result, which is compatible with TCE, is that partners may find opportunities to divide tasks, so that each one of them develops his own in a specific country or group of countries. Thus, the problem of incentives which appears when working as a team is reduced, since the individual performance can be measured with more accuracy, thus laying foundations for the application of the reciprocity mechanism (Teece, 1992; Williamson, 1985). As a consequence, the need to create a JV is reduced.

Another result compatible with the principles of TCE and with previous empirical evidence (Croisier, 1998), is that associated with the Open length variable. The longer

[10] Although our sample is restricted to alliances formed by firms from the EU for the reasons explained in the research setting section, it is worth to point out that we have replicated this table for all of the technological alliances included in SDC from 1992 to 1999 obtaining similar results regarding the significance and sign of the adjusted residual for each category.

the expected duration of the agreement, the greater the propensity to use JVs as a means of protection against uncertainty.

The Cultural distance variable presents a positive and significant effect on the creation of JVs, which confirms the principles of the Organizational Design Approach. In view of the difficulty of coordination among companies, they opt for the creation of a JV.

A remarkable result is that of the variable relating to the effectiveness of the patent protection system (Patent effectiveness). Without any doubt, in those countries where patent effectiveness is low, firms choose to form JVs, so as to guarantee the protection and use of rents associated with technologies. This result confirms that obtained by Oxley (1999) and Hagedoorn et al. (2005).

With regard to the industry of the alliance, we must highlight the different result obtained in relation to the technological intensity of the alliance. Although there are significant differences among industries in terms of their propensity to create JVs, as Hagedoorn and Narula (1996) already pointed out, when we introduce variables relative to the intensity of the industry in estimates including all the relevant control variables, these do not present significant results. In fact, if we exclude variables associated with the characteristics of technological flows and the effectiveness of the patent system from the estimates, we can observe a lesser propensity to create JVs in those alliances created in industries of maximum technological intensity.[11]

A result that contradicts those obtained by previous literature is that relative to direct competition among partners (see Direct competition variable). As we can see in Table 6, such competition reduces the need to create JVs. Although this result is only significant with the specification of 3 digit SIC codes, we think that this is the best way to approach cooperation among competitors allowed by the SDC dataset. The result is to some extent counterintuitive, because rival partners have a greater absorptive capacity (Park and Russo, 1996) and greater possibilities of exploiting knowledge received, which in turn increases appropriability hazards. However, absorptive capacity renders the formation of JVs less necessary given that it clearly facilitates technology transfer (Colombo, 2003).

The Previous relationship variable, as model 3 shows, does not present a significant effect on the probability of forming JVs. Nevertheless, it must be pointed out that, generally speaking, all independent and control variables included in the estimates of this model present similar coefficients to those of other models, which shows the robustness and consistency of our results.

The results obtained in this work have not allowed us to clarify the influence on the choice of contractual form exercized by previous cooperative relationships among partners. This undoubtedly continues to be an aspect that invites more in-depth study, with new research works which may help shed some light on the incidence of this variable.

5. Conclusion

The present work has studied factors influencing the propensity to form JVs in technology alliances. Although a lot of authors have argued in favour of R&D alliances or even all technological alliances having a higher propensity to form JVs, and some have even found evidence in support of their argument; other authors have found a lower propensity to form JVs in these alliances, as Table 1 shows. For this reason our study was aimed at providing a theoretical explanation enabling us to predict what to expect from each type of technological alliance, depending on existing technological flows, and thus to clarify contradictory results obtained by previous research.

Our research has allowed us to confirm the important role played by technological flows in the formation of JVs. Unlike previous literature, our results show that not all technology alliances have the same propensity to create JVs. There will be a greater propensity to create JVs in those alliances in which it is more difficult for the partners involved to control the activities of the alliance and/or where there are more difficulties in distributing cooperation rents according to contributions made, irrespective of the industry to which the activities of the agreement belong. Specifically, our main argument is that there will be a greater propensity to create JVs in alliances in which already existing technologies are combined and in those which try to conduct joint R&D without starting from specific partners' previous technologies.

Nevertheless, this research has limitations that should be taken into account when it comes to generalising our results. In the first place, although we have used a wide sample, including partners from multiple countries, we have only focused on alliances of a technological nature. The application of these results to other types of alliances without such content must be done cautiously. Moreover, certain aspects are not included in the dataset, aspects such us specific clauses included in contracts and other

[11] In order to avoid the inclusion of too many tables in this work, the results of these models have not been presented, although they are available from the author upon request.

relevant information such as the degree of similarity between technologies brought by different partners to the alliance—a key variable from the competences perspective on alliances (Colombo, 2003). It should therefore be noted that there are factors that could not be included in the estimates. It should also be noted that this is so in spite of having used one of the most exhaustive and reliable datasets in the world, and having controlled all the factors analysed in previous literature.

Taking these limitations into account, we can say that there are still some aspects related to the creation of JVs deserving of researchers' attention. Specifically, we may observe in relation to the results of our research that there are different ways of extending and clarifying these same results. In the first place, carrying out empirical studies which include alliances of all kinds and which clarify the effect of variables which have not so far presented conclusive results, such as geographical domain, previous relationships or direct competition. Another way of extending this work would be to carry out in-depth studies of certain alliances which could provide detailed information about exact clauses of contracts, like Lerner and Merges (1998) or the complete track record of previous cooperative relationships between partners, like Ryall and Sampson (2006). In this way, the existing interrelation between the presences of previous cooperative relationships, the inclusion of certain contractual clauses and the formation of JVs could all be explored. In addition, some recent papers analyse determining factors in the adoption of different types of contractual agreements: formal and relational (Carson et al., 2006; Ariño and Reuer, 2006). One way to expand our framework would be to consider that there are different types of JVs – based on the ownership structure – and also different types of contractual agreements; finding the match between all of them and the technological flows proposed in this paper would be an interesting project which would nevertheless need a different dataset to the one used here.

Acknowledgements

Thanks to Carlos Arias and three anonymous reviewers for their suggestions. We gratefully acknowledge financial support provided by the Spanish Ministry of Education and Science and FEDER (Projects SEC 2003-08069 and SEJ2007-67329).

References

Aldrich J.H., Nelson F.D., 1984. Linear probability, logit, and probit models, Sage University Paper Series on Quantitative Applications in the Social Sciences 07-045. Sage, Beverly Hills.

Ariño, A., Reuer, J.J. (Eds.), 2006. Strategic Alliances. Governance and Contracts Contractual Design. Palgrave McMillan.

Arora, A., Fosfuri, A., Gambardella, A., 2001. Markets for Technology: Economics of Innovation and Corporate Strategy. MIT Press, Cambridge, MA.

Arora, A., Merges, R.P., 2004. Specialized supply firms, property rights and firm boundaries. Industrial and Corporate Change 13, 451–475.

Barzel, Y., 1982. Measurement costs and the organization of markets. Journal of Law and Economics 25, 27–48.

Barzel, Y., 1989. Economic Analysis of Property Rights. Cambridge University Press, Cambridge.

Borys, B., Jemison, D.B., 1989. Hybrid arrangements as strategic alliances: theoretical issues in organizational combinations. Academy of Management Review 14, 234–249.

Burt, R.S., 1982. Toward a Structural Theory of Action. Academic Press, New York.

Carson, S.J., Madhok, A., Tao, W., 2006. Uncertainty, opportunism, and governance: the effects of volatility and ambiguity on formal and relational contracting. Academy of Management Journal 49, 1058–1077.

Casciaro, T., 2003. Determinants of governance structure in alliances: the role of strategic, task, and partner uncertainties. Industrial and Corporate Change 12, 1223–1251.

Colombo, M.G., 2003. Alliance form: a test of the contractual and competence perspectives. Strategic Management Journal 24, 1209–1229.

Colombo, M.G., Grilli, L., Piva, E., 2006. In search of complementary assets: the determinants of alliance formation of high-tech start-ups. Research Policy 35, 1166–1199.

Contractor, F.J., Ra, W., 1998. Sharing the fruits of knowledge transfer: a general approach for negotiating alliance contracts from a strategy and finance perspective. Working Paper. Rutgers University.

Croisier, B., 1998. The governance of external research: empirical test of some transaction-cost related factors. R&D Management 28, 289–298.

Galbraith, J.R., 1977. Organization Design. Addison-Wesley, Reading.

García-Canal, E., 1996. Contractual form in domestic and international strategic alliances. Organization Studies 17, 773–794.

García-Canal, E., Valdés-Llaneza, A., Ariño, A., 2003. Effectiveness of dyadic and multi-party joint ventures. Organization Studies 24, 743–770.

Ginarte, J.C., Park, W.G., 1997. Determinants of patent rights: a cross-national study. Research Policy 26, 283–301.

Granovetter, M., 1985. Economic action and social structure: the problem of embeddedness. American Journal of Sociology 91, 481–510.

Gulati, R., 1995. Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. Academy of Management Journal 38, 85–112.

Gulati, R., Singh, H., 1998. The architecture of cooperation: managing coordination costs and appropriation concerns in strategic alliances. Administrative Science Quarterly December, 781–814.

Haberman, S.J., 1978. Analysis of Qualitative Data. 1. Introductory topics. Academic Press, New York.

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

Hagedoorn, J., 2003. Sharing intellectual property rights. An exploratory study of joint patenting amongst companies. Industrial and Corporate Change 12, 1035–1050.

Hagedoorn, J., Cloodt, D., van Kranenburg, H., 2005. Intellectual property rights and the governance of international R&D partnerships. Journal of International Business Studies 36, 175–186.

Hagedoorn, J., Narula, R., 1996. Choosing organizational modes of strategic technology partnering: international and sectorial differences. Journal of International Business Studies Second Quarter, 265–284.

Hagedoorn, J., Osborn, R.N., 2002. Inter-firm R&D partnerships: major theories and trends since 1960. In: Contractor, F.J., Lorange, P. (Eds.), Cooperative Strategies and Alliances. Pergamon, Oxford, pp. 517–542.

Hagedoorn, J., van Kranenburg, H., Osborn, R.N., 2003. Joint patenting amongst companies. Exploring the effect of inter-firm R&D partnering and experience. Managerial and Decision Economics 24, 71–84.

Hamel, G., Prahalad, C.K., 1994. Competing for the Future. Harvard Business School Press, Boston, Mass.

Hofstede, G., 2001. Culture's Consequences: International Differences in Work-Related Values, second ed. [first ed. in 1980]. Sage Publications, Beverly Hills.

Kennedy, P., 1998. A Guide to Econometrics, fourth ed. The MIT Press, Cambridge, Massachusetts.

Kim, K., Park, J., 2002. The determinants of value creation for partner firms in the global alliance context. Management International Review 42, 361–384.

Kogut, B., 1988. Joint ventures: theoretical and empirical perspectives. Strategic Management Journal 9, 319–332.

Kogut, B., Singh, H., 1988. The effect of national culture on the choice of entry mode. Journal of International Business Studies 19, 411–432.

Lawence, P.R., Lorch, J.W., 1967. Organization and Environment: Managing Differentiation and Integration. Division of Research, Graduate School of Business Administration, Harvard University, Boston.

Lerner, J., Merges, R.P., 1998. The control of technology alliances: an empirical analysis of the biotechnology industry. The Journal of Industrial Economics XLVI, 125–156.

Merges, R.P., 1999. Intellectual property rights, input markets, and the value of intangible assets. Working Paper. U.C. Berkeley (Boalt Hall) School of Law.

Morris, D., Hergert, M., 1987. Trends in international collaborative agreements. Columbia Journal of World Business 22, 15–21.

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

Nelson, R., Winter, S., 1982. An Evolutionary Theory of Economic Change. Belknap Press, Cambridge, MA.

Nooteboom, B., 1999. Innovation and inter-firm linkages: new implications for policy. Research Policy 28, 793–805.

OECD, 1999. Science, Technology and Industry Scoreboard: Benchmarking Knowledge-Based Economies. OECD, Bruselas.

OECD, 2001. Science, Technology and Industry Scoreboard: Towards a Knowledge-Based Economy. OECD, Bruselas.

Osborn, R.N., Baughn, C.C., 1990. Forms of interorganizational governance for multinational alliances. Academy of Management Journal 33, 503–519.

Oxley, J.E., 1997. Appropriability hazards and governance in strategic alliances: a transaction cost approach. Journal of Law Economics and Organization 13, 387–409.

Oxley, J.E., 1999. Institutional environment and the mechanisms of governance: the impact of intellectual property protection on the structure of inter-firm alliances. Journal of Economic Behavior and Organization 38, 283–309.

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

Park, S.H., Russo, M.V., 1996. When competition eclipses cooperation: an event history analysis of joint venture failure. Management Science 42, 875–890.

Park, W., 1999. Measuring global patent protection. Fraser Forum, Fraser Institute, Vancouver, B.C., March 4–7.

Pisano, G.P., 1989. Using equity participation to support exchange: evidence from the biotechnology industry. Journal of Law Economics and Organization 35, 109–126.

Pisano, G.P., 1990. The R&D boundaries of the firm: an empirical analysis. Administrative Science Quarterly 35, 153–176.

Pisano, G.P., 2006. Profiting from innovation and the intellectual property revolution. Research Policy 35, 1122–1130.

Pisano, G.P., Russo, M.V., Teece, D.J., 1988. Joint ventures and collaborative arrangements in the telecommunications equipment industry. In: Mowery, D.C. (Ed.), International Collaborative Ventures in U.S. Manufacturing. Ballinger, Cambridge, pp. 23–70.

Prahalad, C.K., Hamel, G., 1990. The core competence of the corporation. Harvard Business Review 9, 79–91.

Reuer, J.J., Ariño, A., 2002. Contractual renegotiations in strategic alliances. Journal of Management 28, 47–68.

Rialp, J., Salas, V., 2002. La colaboración empresarial desde la teoría de los derechos de propiedad. Investigaciones Económicas XXVI, 113–144.

Rothaermel, F., Deeds, D., 2004. Exploration and exploitation alliances in biotechnology: a system of new product development. Strategic Management Journal 25, 201–225.

Ryall, M., Sampson, R., 2006. Do prior alliances influence contract structure? In: Ariño, A., Reuer, J.J. (Eds.), Strategic Alliances. Governance and Contracts Contractual Design. Palgrave McMillan, pp. 206–216.

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

Somaya, D., Teece, D.J., 2001. Combining patented inventions in multi-invention products: transactional challenges and organizational choices. Working Paper. University of Maryland.

Tallman, S., Phene, A., 2006. Governance mechanism in high technology alliances: the biotechnology case. In: Ariño, A., Reuer, J.J. (Eds.), Strategic Alliances. Governance and Contracts Contractual Design. Palgrave McMillan, pp. 67–76.

Teece, D.J., 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. Research Policy 15, 285–305.

Teece, D.J., 1992. Competition, cooperation, and innovation. Organizational arrangements for regimes of rapid technological progress. Journal of Economic Behavior and Organization 18, 1–25.

Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strategic Management Journal 18, 509–533.

Thompson, J.D., 1967. Organizations in Action. McGraw-Hill, New York.

UNCTAD, 2005. World Investment Report 2005: transnational corporations and the internalization of R&D. United Nations, New York.

Veugelers, R., Cassiman, B., 1999. Make and buy in innovation strategies: evidence from Belgian manufacturing firms. Research Policy 28, 63–80.

von Hippel, E., 1988. The Sources of Innovation. Oxford, New York.

Walker, G., Weber, D., 1984. A transaction cost approach to make-or-buy decisions. Administrative Science Quarterly 29, 373–391.

Williamson, O.E., 1985. The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting. Free Press, New York.

Williamson, O.E., 1996. The Mechanisms of Governance. Oxford University Press.