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International R&D cooperation: the effects of distance on the choice of the country of partners

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The objective of this article is to evaluate the impact of the initial context of companies on their propensity to cooperate and on the characteristics of partner companies that they consider to be significant. More specifically, the authors attempt to measure the influence of different dimensions of distance (cultural, administrative, geographic, economic and technological) on the choice of the country of partners in international R&D cooperation. Based on the contribution of the literature on international business and the framework proposed by Ghemawat (2001), this article develops several hypotheses concerning the effects of distance, analysed by five different dimensions. These hypotheses are tested on a sample of 1502 international agreements concluded by European companies in the biotechnology industry. The findings of the empirical study show that distance influences the choice of the country of partners, but that the impact varies according to the dimension analysed and the context of the agreement. In particular, they reveal that administrative, geographic, economic and technological distance plays an essential role, whereas cultural distance does not have a significant influence on the choice of the country of partners, at least in the biotechnology industry and when projects are subsidised.

Key words: International cooperation, distance, choice of partner, research and development, national environment.

INTRODUCTION

This research is part of studies concerning the international development of companies, and more specifically concerning cooperation agreements signed with partners located abroad. It looks at the external environment of organisations, attempting to identify which dimen-

sions are of pivotal importance in choosing a partner for international cooperation on R&D. Thus, while most research focusing on cooperation strategies tends to adopt an internal approach, deriving in most cases from the work of Barney (1991) and Wernerfelt (1984), we have chosen to adopt an external standpoint, preferring to look at the approach developed notably by Porter (Industry Structure View). Driven by a manifest phenomenon of intellectual fashion favouring the approach of RBV or Resource Based View, recent research on choice of co-operation partners has tended to neglect the structural and environmental aspects to concentrate solely on the internal resources and skills of partner organisations. However, firms continue to a large extent to be affected by external aspects, the effects of which are definite, and not always negligible (Christmann *et al.,* 1999), especially in the perspective of international expansion.

In particular, when potential partners for R&D cooperation are operating in different national environments, the distance between them appears likely to shape their decision to sign an agreement and the modalities of their cooperation (Hagedoorn et al., 2005). However, distance is a multi-dimensional concept which is invariably difficult to assess, and until now it has been essentially studied in the analysis of internationalisation processes, initiated by the pioneering work of Johanson and Vahlne (1977). In this context, the focus has been on the cultural dimension of distance, while other dimensions of distance have been neglected, even if its influence on internationalisation processes is not clearly established (Tihanyi *et al.,* 2005). However, in the case of an international cooperation agreement, the company generally needs to manage several forms of distance between its national environment and the environment of its potential partners.

Considering these different contributions, the objective of this article is to evaluate the relative importance of different forms of distance for the choice of the country of partners in international R&D cooperation. In other words, it aims to contribute to the research concerning the formation of international cooperation agreements and to the elements influencing the choice of a foreign partner by concretely and objectively seizing the multiple forms of the distance. To achieve this objective, we have chosen to use the conceptual framework proposed by Ghemawat (2001). However, to the four forms of distance differentiated by the author (cultural, administrative, geographic and economic), we have added a fifth dimension, that of technology, to appreciate the impact of different dimensions of distance on 1502 international agreements concluded by European firms in the biotechnology industry. According to the chosen framework, the analysis concerns the 'macro' level of the choice of countries and is based on the differences between countries where potential partners are located.

In the first section, we examine the role of distance in the international development of companies, and more specifically in international R&D cooperation. The second section is devoted to a presentation of the empirical study and discussion of the results obtained.

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DISTANCE(S) AND INTERNATIONAL COOPERATION

When a company decides to enter foreign markets, it has to deal with distance between its home country and the countries where it intends to develop. Many contributions on internationalisation integrate the concept of distance, which remains operationalised in a rather heterogeneous way. However, if the literature admits that distance plays a role in the process of internationalisation, its impact (and the sense of its impact) has not been clearly established. Thus, before defining the concept of distance more specifically and assessing its effects on the choice of a partner in the development of international R&D cooperation, it seems necessary to examine the role of distance in the literature focusing on the international development of companies.

The concept of distance and the internationalisation of firms

Despite the effects of economic globalisation and increasing integration of regional economic spaces, distance continues to influence the international development of companies. In the literature dedicated to the internationalisation of companies, many authors have attempted to analyse the concept of distance and its effects on decisions linked to foreign market entry.

This is the case of research in international business that defines the notion of distance through the more general concept of 'psychic ditance' put forward in the Uppsala model. Developed by Johanson and Vahlne (1977), this model recommends a progressive approach to foreign markets, allowing the company to benefit from learning effects.

According to the authors, companies that internationalise are confronted with a lack of knowledge concerning foreign markets (lack of market knowledge) which mainly originates from psychic distance as it is perceived by managers and which separates different countries, that is 'the sum of factors preventing or disturbing the flows of information between firms and markets' (Johanson and Wiedersheim-Paul, 1975, p. 308). This definition, which is relatively broad, leaves room for different elements such as differences in language, education systems, managerial practices, cultures and industrial development. Johanson and Wiedersheim-Paul (1975) and Johanson and Vahlne (1977) use the concept of psychic distance to support the linear and incremental conception of internationalisation processes. Thus, to overcome the lack of knowledge of foreign markets, which represents an obstacle to international development, managers tend to prefer, as a first step, to enter countries which represent a certain psychic proximity with their country of origin. Then, once companies' international experience increases, their psychic distance from other geographic areas is reduced, allowing companies to develop in initially more distant countries.

In this analytical context, distance represents a determinant of the in-

ternational development of firms and the major difficulty is that of its operationalisation (Brewer, 2007).

Despite its attractiveness, this approach has recently been questioned by research on 'born globals'. From this perspective, the internationalisation process is no longer considered as incremental and linear; in fact, the opposite is true, because the company is perceived as an economic model which is immediately defined at an international level. For researchers adopting this approach, companies attempt, from their creation, to construct competitive advantage by directly using or selling their products in many countries (Knight and Cavusgil, 2004; Oviatt and McDougall, 1994; Zucchella and Scabini, 2007). Thus, not all companies internationalise in countries with increasing psychic distance or use the reduction of distance step suggested by the Uppsala model.
Besides the emergence of alternative approaches to the international development of companies questioning the role of distance, it seems important to emphasise that psychic distance remains difficult to operationalise (Evans and Mavondo, 2002) and that its different attributes remain controversial (Brewer, 2007; O'Grady and Lane, 1996). In fact, many studies relate to the concept of psychic distance by relying only on cultural distance or by including different aspects such as the economy of the foreign market, the political system, time zones or the climate. However, even if psychic distance is often assimilated with cultural distance, the two notions, even if they cover similar aspects, are not equivalent. Thus, psychic distance is specific to the firm and evolves according to the experience acquired on international markets.
Moreover, psychic distance covers a broader reality than cultural distance (Brewer, 2007; O'Grady and Lane, 1996), even though the latter continues to be used in many empirical investigations (for example, Delios and Henisz, 2003a et b), especially since its operationalisation by Kogut and Singh (1988). For the two authors, cultural distance expresses the degree of separation between two national cultures, in other words, between two systems of ideas and values shared by the members of a given group. In contrast to psychic distance, cultural distance thus concerns two nations (and not the firm) and therefore presents a more static character. The index proposed by Kogut and Singh (1988), which is based on the indices observed by Hofstede (2001) for four cultural dimensions, allows cultural distance to be calculated for different countries. The empirical investigations conducted by Hofstede (2001) allow precise scores to be given to about fifty countries for four identified cultural dimensions:

- Power distance refers to the perception of the degree of inequality in power between those who hold power and those subject to it. It reflects the distance between different ranks within an organisation and the way in which inequality between individuals is handled.
- Uncertainty avoidance is a dimension 'measuring the degree of tolerance a culture has with respect to disquietude resulting

from an unknown future; if tolerance is low, avoidance will be high, and vice versa' (Bollinger and Hofstede, 1987, p. 103).

- The 'individualism/collectivism' dimension refers to the relationship between individuals and other members of society. It determines the perception of the relationship between the individual and the group.
- The 'masculinity/femininity' dimension refers to a society's allocation of roles between men and women (Bollinger and Hofstede, 1987; Hofstede, 2001).

While the impact of cultural distance on international corporate development has been examined in many empirical studies, its effects on internationalisation processes continue to be the subject of considerable debate (Ambos and Ambos, 2009; Brouthers and Brouthers, 2001; Shenkar, 2001; Stahl and Voigt, 2008). Some authors even argue that cultural or psychic distance does not necessarily represent an obstacle to the internationalisation of activities, because a weak psychic distance can make managers less attentive to differences and thus reduce learning effects (O'Grady and Lane, 1996). A meta-analysis of available empirical studies confirms that a large cultural distance will usually reduce companies capital commitment of companies to international operations (Tihanyi *et al.,* 2005).

Alongside this, and without neglecting the role of cultural distance, many scholars in international business have studied the impact of the institutional context of countries on entry modes preferred by companies. In this sense, the research conducted by Delios and Henisz (2000, 2003a and b) on the internationalisation strategies of Japanese firms shows, for instance, that the institutional (or political) environment of a country can be a source of uncertainty and thus have a significant impact on the choice of investments. According to the authors, the institutional environment concerns laws, regulations, administrative procedures and politics developed by the government of a country. Based on the analysis of investments made by 665 Japanese firms in 49 countries for the period from 1980 to 1998, their studies also indicate that firms tend to adapt their investment policy according to the levels of uncertainty associated with different institutional contexts. Delios and Henisz (2000, 2003a and b) demonstrate that the uncertainty linked to the institutional context not only influences the initial choice of entry mode, but also the evolution of investments. In other words, it is only through a sequential development that companies can benefit from a learning effect concerning the institutional context of the countries involved. The authors emphasise that uncertainty linked to the institutional context should be considered in explanatory models of internationalisation at the same level as uncertainty associated with cultural differences and the specific characteristics of foreign markets.

The importance of the institutional context is also highlighted by the research conducted by Eden and Miller (2004) who show that institutional distance is likely to generate specific costs which influence market entry modes preferred by multinational companies. More generally, they consider that the institutional distance between the country of origin of the multinational company and the foreign country reduces the

capitalistic commitment of multinational com-panies.

Research on the internationalisation of firms clearly shows that the concept of distance is a multidimensional concept. The latter has been declined in many ways by differentiating, alternatively or jointly, linguistic and/or cultural gaps, institutional distances between countries, and sometimes by even including differences in commercial practices or economic gaps between the national context of the company and the markets it intends to enter[1].

1. A synthesis of the different definitions of the concept of distance is provided by the article of Brewer (2007).

Given this diversity, and in order to sum up the multiple aspects of distance mentioned in the literature, Ghemawat (2001) recently proposed a suitable conceptual framework known as the "CAGE (*cultural, administrative, geographic, economic*) *distance framework* which make it possible to distinguish between four forms of distance that are likely to influence the international development of companies: (1) cultural, (2) administrative (or legal), (3) geographic and (4) economic distance. The author explains and illustrates each dimension, but does not provide details about their operationalisation. By categorising the different dimensions inherent to the notion of distance, the author's contribution can be used as an analytical framework for examining the role of distance for international operations in general and for cooperative strategies in particular. This is the option adopted in this research which focuses on the role of distance in the conclusion of international R&D cooperation.

In fact, where their international development is concerned, companies can choose to form cross-border cooperation agreements. Distance is thus likely to influence certain decisions, namely the choice of the partner located abroad. This decision is particularly important, because the compatibility of partners is a necessary condition for the success of the cooperation agreement (Doz and Hamel, 2000).

The influence of distance on international R&D cooperation

In knowledge-based economy, many actors decide to form international cooperation agreements in the field of research and development (Ohmae, 1995), that is agreements signed between independent organisations (private enterprises or public research laboratories), located in different countries, which combine resources and skills with the aim of carrying out a common R&D project. The goals pursued by partner organisations are often similar: the sharing of costs and risks linked to the development of new products and processes, learning and transfer of knowledge, creation of new knowledge, skills and capabilities (Barthélémy *et al.,* 2001; Hagedoorn and Narula, 1996). However, given the risks intrinsic to any cooperative project, the achievement of the goals as initially defined can in many cases be seen as problematic. In the light of the issues involved, R&D agreements are frequently subject to tension or even conflict which the partners can prevent by carefully choosing their ally or allies (Pitsis *et al.*, 2004; Puthod and Thévenard-Puthod, 2006).

In fact, when a company engages in cooperation on R&D, it is faced with a degree of uncertainty arising from the incomplete nature of the

contracts signed. This is so because it is difficult, or even impossible, to determine the exact nature of the knowledge that will be created by the cooperative project or to anticipate the use and value of that knowledge. Furthermore, information asymmetry means that a company cannot evaluate its partners' ability to create knowledge in any precise way (O'Sullivan, 2005). In his research, Hennart (1982) also shows that this uncertainty is likely to increase transaction costs; companies can thus prefer the internalisation of activities to the choice of the market or the adoption of hybrid forms of organisation (e.g. licensing or franchising agreements). Moreover, recent contributions reveal that uncertainty is aggravated in the case of international cooperation, where the company is involved with a partner operating in a different context (Delios and Henisz, 2003; Hagedoorn *et al.,* 2005).
In practice, such cooperation agreements can bring together two or more organisations from the private sector or the scientific world. Multilateral cooperation on R&D is often conducted within a consortium framework or a grouping of organisations formed for such a project, allowing the associated firms to access resources that are difficult to transfer and/or to create new resources and skills (Barthélémy *et al.,* 2001). In Europe, consortium formation has been facilitated by the implementation of a number of EU programmes such as Eureka projects, the aim of which is to enhance the competitiveness of European companies, or the multiyear Framework Programme for Research and Technological Development, put in place by the European Union, under which cooperative arrangements take the form of programmes whose costs are shared. In any event, when a company decides to enter into a cooperation agreement with a partner based in another country, it will inevitably need to cope with the distance between its home country and the country or countries of the partner(s), notably because of the increased the level of uncertainty or perceived risk involved in these cross-border operations (Henisz and Macher, 2004). Thus, it seems interesting to examine the impact of the different dimensions of distance as presented in the CAGE model developed by Ghemawat (2001) on the choice of a partner located in a foreign country. The following paragraphs are dedicated to each of the four dimensions put forward by the author. We suggest adding a fifth dimension relating to technology, which is also likely to influence the morphology of cooperation agreements (Hagedoorn *et al.,* 2005).

Cultural distance, the first dimension analysed in the analytical framework proposed by Ghemawat (2001), continues to receive the most attention in the literature, including in the context of international cooperation. It results from a range of factors such as differences in language, ethnicity, religious beliefs, and social norms. It influences the way in which individuals interact with each other and with companies and institutions (Ghemawat, 2001; Tyrrell, 2004). In the context of inter-firm agreements, many studies emphasise the necessary cultural compatibility of partners (Pothukuchi *et al.,* 2002), arguing that the similarity of allies' norms and values is likely to facilitate their interactions and exchanges (Lane and Lubatkin, 1998). More generally, it is hypoth-

esised that the heterogeneity of cultural environments of partners favours comprehension problems linked to differences in interpretation and perception (Parkhe 1991; Pothukuchi *et al.,* 2002). Moreover, culturally distant organisations would interpret and treat information and events that are likely to disturb the initiation and development of the collaboration in a different way (Parkhe, 1991). The cultural dimension thus seems essential in R&D cooperation, where exchanges between partners, linked to the transfer and creation of knowledge, are frequent (Barthélémy *et al.,* 2001). Conversely, cultural distance can also be considered as a source of complementarity (Yeheskel *et al.,* 2001), favouring creativity (Blanchot, 2008). A meta-analysis of the impact of cultural differences on the performance of mergers and acquisitions recently offered by Stahl and Voigt (2008) even shows that cultural distance can have positive and negative effects. However, it seems important to observe that in the case of R&D partnerships, the positive aspects of diversity seem rapidly to be balanced or obscured by its negative effects, particularly as far as the transfer of knowledge is concerned (Ambos and Ambos, 2009), which makes it possible to hypothesise that when a company needs to select a partner located in a foreign country, the most favoured choice will be an organisation whose national culture is relatively close.

H1: *The more distant countries where organisations operate are in terms of culture, the less likely it will be that those organisations form R&D partnerships.*

Administrative (or political) distance relates essentially to history, membership of different political, economic or monetary unions (e.g. increasing integration in the European Union is reducing the administrative distance between member states), potential political hostility, government policy and the institutional or legal context (Ghemawat, 2001). In contrast to cultural distance, this dimension of distance has not been widely studied. One of the most prominent attempts in this field is the construction of the index of political constraints (POLCON) elaborated by Henisz (2002), which measures the feasibility of changes in political orientation in 234 countries according to the structure of their political institutions. Independently from these attempts at measurement, few large-scale empirical investigations currently consider the administrative aspect of distance in internationalisation processes and thus in the context of cooperation, presumably because of the multiple definitions which make measurement more problematic. In fact, several distinct orientations can be observed in the literature, which sometimes represents the dimension only in terms of its administrative or procedural aspects, and sometimes including certain institutional or political aspects (Henisz, 2002), or legal (Evans and Mavondo, 2002) or historical aspects (Brewer, 2007; Ghemawhat, 2001) also. The effects of this dimension of distance on companies' international operations can be significant (Delios and Henisz, 2000, 2003a and b; Henisz, 2002; Henisz and Macher, 2004). In this context, for example, the France's limited appeal as a location for foreign multinational companies' R&D activities in pharmacology can partly be explained by the difficulties encountered

in conducting clinical tests in satisfactory conditions, linked 'to the administrative procedures and the negative image of clinical research in the public administration and at the hospital' (Sachwald, 2004, p. 17). As for the choice of location, significant differences between the institutional contexts of partners will usually make cooperation more difficult (Parkhe, 1991). In particular, the institutional context of a country can be a source of uncertainty and play a significant role in companies' choices in terms of investments (Delios and Henisz, 2000, 2003a and b). When putting a cooperative R&D project in place, a company needs to pay particular attention to its partner's legislative framework.
Indeed, national legislative systems continue to show substantial differences (legislation on patents, contract performance, for example), which can be a major impediment to R&D cooperation (Hagedoorn *et al.,* 2005), because these differences increase uncertainty and the risks of opportunism (Hennart, 1982), and more specifically when technologies concerned by the agreement are new or emerging. Substantial legal distance is therefore likely to limit companies' willingness to engage in a cooperative R&D project.
H2: *The more significant differences between national administrative contexts in which organisations operate become, the less likely it will be that those organisations form R&D partnerships.*

The notion of distance immediately relates to **geographic distance,** which is its most visible and intuitive dimension. It refers to the physical distance existing between the countries or geographic spaces in which the partners are operating. It results from a range of factors such as the absence of a common national border, transport (allowing access by sea, river, train or road) and communication infrastructures. Such factors are likely to generate specific costs such as those arising from transport or communication (Ghemawat, 2001). Geographic distance can thus appear as an obstacle to the development of international economic relationships. Geographic distance can also affect the choice of an R&D partner. However, in this field, it is essentially the literature on spillovers[2] and the regional economy which has analysed this notion by showing its role in the exchange of knowledge. As a pioneer of research on technological externalities, Griliches (1979) has initiated many theoretical and empirical studies by introducing and developing an index of geographic coincidence in the function of knowledge production. Following the conclusions of his research, which have since been confirmed by several empirical investigations, he hypothesised a strong geographic dimension concerning the effects of public research on the innovation capacity of surrounding firms. Thus, the geographic proximity of partners of R&D cooperation seems desirable because it favours the internalisation of these externalities by facilitating the transfer of knowledge.
The research of the author is reflected in many current studies that emphasise the necessity of face-to-face interactions between R&D partners. The idea is that significant geographic distance makes the transfer of knowledge between different entities more difficult because the personal contacts and interactions between the teams involved be-

2. An externality (or spillover) exists when an economic exchange affects another actor and when this effect does not act through the system of prices. This is the case, for instance, when R&D expenses of an actor contribute to increase the stock of knowledge of another actor.

come less frequent (Hansen and Lovas, 2004; Shenkar, 2001), for example because of time differences between partners and the length of transmission channels (Ambos and Ambos, 2009). However, even before the conclusion of the agreement, geographic distance can have an impact on the choice of a partner located in a foreign country, because companies tend to prefer partners operating in an environment that seems close, that they have already met or that they know. Beise and Stahl (1999) show that it is essentially for reasons of convenience that these links are more intense in concentrated geographic areas. Therefore, physical distance is likely to reduce the probability that cooperation opportunities will be identified. Finally, the costs generated by **geographic distance** can be significant for activities such as R&D which require an high degree of coordination, inciting companies to prefer a partner that is physically close. Given all these elements, we can assume that geographic distance is likely to reduce the willingness of companies to form R&D cooperation agreements.

H3: *The more geographically distant countries where organisations operate are, the less likely it will be that these organisations form R&D partnerships.*

As for **economic distance**, this is the result of differences between countries in terms of their economic wealth as well as the cost and quality of the available natural, financial and human resources (Ghemawat, 2001). Economic distance between countries can be quantified using a number of indicators, such as the Gross National Product (GNP) per capita, the growth rate, or the degree of openness to international trade (Hagedoorn *et al.,* 2005). More generally speaking, it is in the field of international economics that this dimension of distance has often been examined, and notably in the formulation of gravity models, named in reference to Newton's. In fact, the impact of economic differences is a fundamental component of the calculation of gravity equations, supposed to predict bilateral exchange flows between countries. These calculations of potential exchange between countries are based on the notions of attraction (linked to the 'mass' relative to countries associated with economic flows) and of repulsion (which derives from the distance, in a large sense, separating the co-contractors) (Fontagné *et al.,* 2002). In this context, the respective revenues of partner countries are thus considered, if they are close, as representing a force of attraction stimulating the volume of exchange between nations.

It thus seems relevant to transfer this dimension of distance, which is well known in international economics, to the analysis of R&D cooperation. This is the option chosen by Cabo (1997), who demonstrates that Eureka projects are more frequently concluded between countries with a high and similar level of wealth. In other words, since the economic environment and the availability of resources play an essential role in the field of R&D, one can suppose that companies will preferably collaborate with partners whose economic environment is similar to that of their country of origin. This can be calculated using data from international organisations such as UNCTAD, OECD or the World Bank. The economic environment and the availability of resources play a key

role where R&D is concerned and it can be assumed that companies will prefer to collaborate with partners whose economic environment is similar to that of their home country.
H4: *The more economically distant countries where organisations operate are, the less likely it will be that those organisations form R&D partnerships.*

And lastly, technological distance refers to the difference in levels of technological development in the partners' countries. This dimension is dependent not only on the comparative scope of the countries' national systems for innovation and the presence of technology-intensive industries, but also on the comparative levels of participation in international research programmes (Hagedoorn and Narula, 1996). Absent from the framework proposed by Ghemawhat (2001), and often neglected in the research on the internationalisation of firms (Henisz and Macher, 2004), this dimension of distance seems to be studied more regularly at the 'micro' level of the organisation (Noteboom *et al.,* 2007) or for comparing the basis of knowledge of potential R&D partners (Mowery *et al.,* 1998). However, in the field of R&D, studies concerning factors affecting the internationalisation of activities of multinational companies emphasise the importance of the technological environment of companies (Henisz and Macher, 2004), concerning its scientific and technical characteristics (Sachwald, 2004) as well as the importance and vitality or quality of links established between research activities and the industry of foreign countries.
In this context, Sachwald (2004) shows that the unfavourable perception of innovation policies and developed actions in the field of biotechnologies in France in comparison to those of other countries explains, at least partially, the lower attractiveness of France for R&D activities in this industry. In the same way, Henisz and Macher (2004) emphasise that foreign direct investment by multinational companies partially takes place to benefit from the national innovation system of the foreign country. The authors indicate that, in the industry of semi-conductors, technological differences between countries influence, at least partially, decisions concerning internationalisation. The publications of Porter and Stern (2001) on national innovative capacity also indicate that its role is not inconsiderable, particularly where international operations concern R&D activities.
As for R&D cooperation agreements, the empirical study conducted by Hagedoorn *et al.* (2005) highlights the role played by technological distance by showing that it can represent a major impediment to setting up an international cooperative project. The integration of this dimension of distance in the analysis of links on R&D seems relevant because it can contribute to an increase in the level of uncertainty concerning the signing of the cooperation agreement with a partner located in a distant country in terms of technology. In other words, it is likely that technological and scientific characteristics of the national environment in which potential partners of a cooperation agreement operate help to create a form of distance between them and that they play a role in the configuration of R&D agreements.

On this basis, we can reasonably presume that technological distance between the countries where partner organisations are located will reduce the companies' willingness to enter into R&D partnerships.
H5: *The more distant the countries where organisations operate are in terms of technology, the less likely it will be that those organisations form R&D partnerships.*

EMPIRICAL STUDY

The empirical study focuses on cooperation agreements in the R&D field entered into by European firms operating in the biotechnology industry, bearing in mind that biotechnology is defined as the use of the properties of the living world for the production of materials or services intended for the living world. This is a sector with a network structure par excellence (Owen-Smith *et al.,* 2002) and one in which the size of an operator's portfolio of agreements is crucial. It offers a rich and relevant field of study for the examination of the various dimensions of distance described above. Moreover, this choice allows us to contribute to international business debate, and more specifically the discussions surrounding the international development of companies and 'born globals' mentioned previously. In this analytical context, it has been argued that SMEs in the high technology field, which include companies in the biotechnology industry, internationalise more rapidly by showing a higher degree of interest in the global market from their creation (Knight and Cavusgil, 2004). Internationalisation is not reserved for big companies, and it also increasingly concerns R&D activities (Sachwald, 2004). Finally, the choice of Europe as a field of investigation is based on several empirical studies which show that the location of R&D activities is not uniform but more concentrated in developed countries.

Study methodology and operationalisation of concepts

The five hypotheses formulated were tested on a sample of 1502 R&D partnerships established by European biotechnology firms. The data used in this empirical study were extracted from a database built up in the context of some wider research on the choice of suitable partners for R&D collaboration. This database contains information on three types of R&D cooperation entered into by European biotechnology firms with other companies or scientific bodies during the period 1992-2000. It covers:

- Based on the on-line information system of the European Union (CORDIS) and the CD-ROM with the same name (CORDIS IV, 1999 edition), all multinational cooperative programmes undertaken under the EU's Framework Programmes for Research and Technological Development partly supported by EU subsidies
- Based on the Eureka databank managed by the Eureka office located in Brussels, and accessible via Internet, the various projects conducted under the Eureka label in the medical and biotechnology domain of this pan-European programme and fi-

nanced in most cases by means of repayable fund advances topped up by the partners' national governments
- Based on the specialised press (such as the Biofutur journal for France), reports edited by national associations of biotechnology and websites of European biotechnology companies, other agreements relating to R&D which we qualify as 'non-framework agreements', whether these were subsidised at the national level or not

It is worth noting that for all the cooperative R&D programmes surveyed, only those involving at least one private company were taken into account and the chosen sample concerns only international agreements put in place by partners based in one of the 15 European countries most active in the biotechnology field (cf. **Annex A**). **Table 1** below contains a detailed breakdown of the sample used.

Table 1 – Structure of sample

Number of agreements		**1 502**
including:	Framework Programme (mixed)*	737
	Eureka projects	163
	"Non-framework" agreements	602
Number of co-participation pairings		(15*14)/2

** Only programmes in which the costs were shared, or "mixed" programmes (i.e. with at least one company) were selected for this study. The other projects surveyed in this context involved only scientific bodies.*

The final sample includes agreements concluded in three different contexts. In fact, non-framework R&D agreements do not generally benefit from subsidies and are signed spontaneously between independent organisations. Moreover, our sample includes collaborations signed at the international level so that they can benefit from the Eureka label or from the framework programmes for R&D of the European Union. These two types of projects are part of European programmes intended to promote innovation and exchange of knowledge which generally benefit from subsidies at the national level in the first case and at the EU-level in the second case[3]. Conversely, they are different as concerns their orientation (Eureka projects are closer to the market than projects conducted within the framework programmes for R&D), their degree of centralisation of procedures, which is higher for framework programmes for R&D, and the coordination of projects, which is conducted by companies in Eureka projects (and is rare in the context of framework programmes for R&D).

The fact that projects considered in this research have been concluded in different contexts has an impact on certain characteristics of our sample. In particular, the average number of partners of cooperation agreements in the context of framework programmes for R&D is relatively high (4086), whereas non-framework agreements are mainly bilateral. Another characteristic element of projects concluded in the framework programmes is the index of geographic dispersion, that is, the rela-

3. In the case of France, these subsidies can come from Oséo Innovation, the ministry of research or the ministry of industry. Concretely, a French SME participating to an Eureka project can obtain a financing of reimbursable advance that can achieve about 50% of the budget of its participation to the Eureka project

tionship between the number of countries represented in the project and the total number of partners. The latter is higher in non-framework agreements and Eureka projects than in framework programmes (0.99 compared with 0.74 and 0.68 respectively). Since these contextual differences are not to be neglected and can influence the results obtained, the empirical study presented in this article develops the results at a global level but also at the level of all three categories of agreements.

In practice, and in order to examine the dependent variable of the study, in each context we counted the number of links established between each pair of countries, or, in other words, the number of co-participations between organisations. This is because in order to examine the impact of cultural, administrative, geographic, economic and technological distance on the choice of a partner, an analysis of co-participations (or two-by-two pairings) rather than projects was judged to be more relevant, above all because it enables multilateral projects to be analysed. Moreover, a similar approach had already been employed for an analysis of cooperation agreements established under the EU Framework Programme (e.g. Charlet, 2001), as well as in the context of Eureka consortia (e.g. Hagedoorn and Schakenraad, 1993; Cabo, 1997) and for the analysis of other R&D cooperation agreements described here as non-framework agreements.

Consequently, the variable to be explained corresponds to the Jaccard index for co-participations in EU Framework Programme projects, in the Eureka programme and other non-framework cooperative projects, relating to R&D activities. In fact, this index, sometimes called the 'similarity coefficient', proves to be well-suited to comparisons between co-participation profiles and at the same time provides a clearer idea of the affinities existing between partners of different nationalities than simplyadding up the links established between them. Its use is also justified by the fact that by weighting the links established, it becomes possible to circumvent the 'size' effect due to the non-uniform intensity of the participation of the different countries in the three contexts for collaboration described above[4] (Cabo, 1997). In this way, it allows two-by-two affinity comparisons to be made, putting into perspective values that are comparable for each of the pairings considered. In practice, the Jaccard index for the co-participations is calculated using a count of the pairings involved in the projects examined[5] based on the number of cases in which at least one of the two components of the pair is present:

$$\textit{Jaccard index}_{ij} = \frac{C_{ij}}{C_i + C_j - C_{ij}} \qquad (1)$$

where c_{ij}: is the number of co-participations for country i and country j,
c_i: is the total number of country i participations,
c_j: is the number of country j participations.

To be more precise, three Jaccard indices were calculated for the whole series of 105 pairings in the three collaborative contexts, yielding in

4. Divergence between the number of participations by organisations in the three contexts under consideration is in some cases very substantial, especially for EU Framework Programme projects, in which Germany, France and the United Kingdom account for most participations (cf. Charlet, 2001).

5. Giving pairings per project involving n partners. A project with two partners will form a single pairing and therefore a single co-participation. Conversely, a project involving five partners of different nationalities will form ten pairings, and so on. For a study covering 15 countries, the number of potential pairings is therefore 105.

each case a similarity matrix summarising in line and column form the countries selected for the study, and in which cell cij indicates the sum of the number of pairings identified between partners of nationality i and nationality j. As a reflection of the intensity of the links between pairs created in the three contexts of R&D cooperation, the sum of these indices thus turns out to be highly suitable for the operationalisation of the dependent variable in this empirical study.
The goal of this research is therefore to seek to explain such co-participations in R&D agreements on the basis of the notion of distance seen in terms of its various dimensions. Other than in the special cases referred to below, the distances between a partner in country i and a partner based in country j were calculated as follows:

$$Dist_{ij} = \frac{(score_i - score_j)^2}{\sigma_{.\,distrib}^2} \quad (2)$$

In this way, in order to determine the cultural distance separating partners cooperating in the R&D field, the Hofstede Index (**IndexH**) has been employed in its synthetic aggregate version, based on the work of Kogut and Singh (1988) and which is constructed on the same principles as formula (2) for the measurement of distance used in this research. According to the authors, cultural distance DC_{jk} between country j and country k can be calculated using the following formula:

$$DC_{jk} = \frac{\sum_{i=1}^{4}\left\{\frac{(I_{ij} - I_{ik})^2}{V_i}\right\}}{4} \quad (1)$$

where: I_{ij} is the index for cultural dimension i determined for country j,
I_{ik} is the index for cultural dimension i determined for country k, and
V_i is the variance in the index for cultural dimension i.

While **cultural distance** measurements have been used on numerous occasions, the measurement of administrative distance has proved to be much more problematic, one notable reason being the lack of large-scale empirical studies focusing on it. As a result, in order to assess this dimension of distance, we have selected several indicators based on the different interpretations of this dimension developed above. Firstly, in order to approximate the divergence in legal terms between partners in R&D cooperation, use was made of the index for the protection of intellectual property rights formulated by Ginarte and Park (1997) and calculated by them for a large number of countries. This index is based on five sub-dimensions for which each country is awarded a score between 0 and 1 once every five years (cf. **Annex B**). The unweighted sum of these component values yields a general score on a scale from 0 to 5. Concerning the countries observed in this study, the scores are generally close to 4.5. Even if variations remain relatively reduced between the countries analysed, some differences can be noted. Thus, the Netherlands or France had indexes of 4.54 in 1995 and 4.67 in 2000, while the scores calculated for Norway reached only 3.88 in 1995 and 4 in 2000.

Following this, the distance between partners for this dimension (IPR) was calculated in accordance with formula 2 as presented above and using the average of the scores as calculated by Ginarte and Park (1997) and updated by Park and Wagh (2002) for the period of reference (i.e. 1995 and 2000) for each of the two countries represented.
Secondly, based on the reflexions of Gwartney and Lawson (2003), two components of the economic freedom indicator defined for 123 countries and published by the Fraser Institute in the annual Economic Freedom of the World (EFW) reports were selected as reflecting the legal and administrative system as a whole (legal), to take account of the degree to which the labour, credit and business markets are regulated (regul) in the 15 countries of the sample (cf. Annex B for the composition and sources of these indicators). Thirdly, and following Ghemawat (2001) and Brewer (2007), the joint membership of partner countries to the same economic space (in our case, EFTA, EU and/or Benelux) has been considered for the measurement of administrative distance; this corresponds to the variable comember which reflects the number of economic spaces shared by the allies. Finally, a specific variable (polrisk) enabled the size of the differential in political risk to be taken into account. It reflects the degree of corruption or the scale of social conflicts affecting the country and corresponds to one of the three sub indices calculated and published by the PRS Group, a rating agency, which evaluates the general level of risk in over 150 countries on a fully transparent and multiyear basis (cf. **Annex B**) and which is used in different studies (for example, Meschi, 2008).
Geographic distance could be quantified using two variables: distance in kilometres between the capital cities of the countries where the allied companies were based (Cabo, 1997) and a count of the borders shared by their respective countries (Ghemawat, 2001). To be more precise, the figures used were the logarithms of the distance in kilometres (distkm) and the reciprocal of the number of common borders (limitrophe), which were used to avoid problems of heteroscedascity for the first variable and to convert the proximity expressed by the second into a distance coherent with the other explanatory factors in this study.
For **economic distance**, as suggested by several studies, we used Gross National Product (GNP) per capita (gnpc) to express the difference between the partners' standards of living. However, in this regard, significant differences continue to exist between the countries taken into consideration; this can be seen, for instance, in the difference observed between Norway and Spain, where the difference of the GNP per capita (in parity of purchasing power) is about 9000 euros for the period of study. According to the recommendations of Brewer (2007), this measure was supplemented by the distance between allies in terms of development (HDI) as calculated using the index published annually by the United Nations in connection with its Development Programme and by an assessment of the distance separating the partners in terms of economic risk (ecorisk) for the period under consideration, using the evaluation contained in the PRS group reports (cf. **Annex B**).

Conversely, in this research and with the aim of improving our knowledge of the nature and composition of this dimension, the question arose as to whether the economic dimension of distance should include differences existing between countries in terms of international trade flows. In this regard, the measure proposed here is not limited to the only differences concerning the creation of wealth, but has also attempted to integrate this aspect. Therefore, the economic dimension of distance has also been calculated by two indicators dedicated to measuring the situation of the countries of the partners concerning their international trade:
the comparison of the degree of openness of the economy (openness), measured by the average of imports and exports of goods and services as a ratio of the GDP (Hagedoorn *et al.,* 2005), and the level of exports (trade) of the partners' countries.
And lastly, for **technological distance**, it seemed necessary to take into account not only the partners' general technological level but also the degree of maturity of biotechnology in the countries where the organisations associated under the agreement are operating, because an industry effect is likely to exist for this dimension. To do this, five indicators were chosen: the amount of investment in R&D made by resident enterprises, research institutes, universities and government laboratories, expressed as a ratio to total GDP (GERD), the index of national capacity of innovation (NCI) concerning the period, based on the work of Porter and Stern (2010) (cf. **Annex B**), the level of technological accomplishment (TAI) as shown in UNCTAD reports (cf. **Annex B**), the number of new biotechnology firms (NEB) formed per million inhabitants, and the number of biotechnology patent applications, per million inhabitants, filed with the European Patent Office for each of the 15 countries in the sample. In all, 18 instrumental explanatory variables were selected. They are summarised in Table 2, which also contains details of the information sources used to quantify them.

Table 2 – Summary of explanatory variables and associated data sources

concept	Operationalisation of scores per country	Sources and methods
Cultural distance (C)	- Kogut and Singh (1988) synthetic index	- Hofstede (2001) - Kogut and Singh (1988)
Administrative distance (A)	-Difference in terms of intellectual property rights (IPR) -Difference in terms of legal structures (legal) -Difference in terms of regulation (regul) -Difference in terms of political risk (polrisk) -Membership of economic zones (comember)	- Ginarte and Park (1997), Park (2008) - EFW (various eds) - EFW (various eds) - EFW (various eds) - International Country Risk Guide
Geographic distance (G)	-Logarithm of the distance in km between capital cities (distkm) -Reciprocal of the number of common borders between partners (limitrop)	- Cabo (1997) - Ghemawat (2001)
Economic distance (E)	-Difference in terms of GNP per capita (gnpc) -Difference in terms of openness of the economy (openness) -Difference in terms of level of exports (trade) -Difference in terms of level of development (HDI) -Difference in terms of economic risk (ecorisk)	- Eurostat (online database) - OECD Factbook (various eds) - OECD (online database) and World Bank - Human Development Report (UNDP, various eds) - International Country Risk Guide
Technological distance (T)	-Difference in terms of R&D spending as a percentage of GDP (GERD) -Difference in terms of national innovation capacity (NCI) -Difference in terms of technological accomplishments (TAI) -Difference in terms of new biotech firms/per million population (NEB) -Difference in terms of numbers of biotech patent applications filed with EPO/per million population (biopatent)	- OECD Factbook (various eds) - Porter and Stern (2001) - Human Development Reports (various eds) - Ernst & Young reports (multiple eds) and OECD Biotechnology Statistics (2006) - EUROSTAT (online database)

Results and discussion

The presentation of the statistical results includes an analysis of the correlations, several estimated regression models and the discussion of the results obtained. **Table 3** sets out the **descriptive statistics** and **bivariate correlations** for all the chosen indicators.

Overall, while the vast majority of the explanatory variables tested turn out to be linked negatively to the intensity of coparticipations in R&D cooperative projects, several exceptions can nevertheless be identified. These relate particularly to the variables legal and regul linked to administrative distance whose positive correlations with the measure of co-participations (0.14 and 0.27) reflect the variety of institutional, legal and administrative contexts in which the partners are operating. The positive sign attached to these correlations seems to contradict **hypothesis 2** which, it is recalled, conjectured that there was a negative relationship between these two concepts.

However, with the exception of the variables already mentioned, all the other correlations are aligned with the hypotheses formulated above. Their examination also reveals certain problems of multicollinearity between the independent variables of the study, justifying the reduction of the data using factorial analysis before applying regression analysis. This intermediate data-reduction stage is explained in box 1, which proves a broad outline of the statistical treatment processes applied. It is followed by the regressions, the results of which are now described in brief.

Table 3 – Descriptive statistics and correlations

	variable	mean	sd	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	CoPart	0,03	0,02	1																				
2	IndexH	2,22	1,37	-0,05	1																			
3	IPR	2,19	3,01	-0,15	0,01	1																		
4	polrisk	2,45	3,13	-0,02	0,1	-0,14	1																	
5	legal	2,36	2,8	0,14	0,27	-0,16	0,74	1																
6	regul	2,41	3,27	0,27	0,11	0,15	0,32	0,46	1															
7	comember	0,75	0,46	0,45	0,22	-0,56	-0,02	0,18	0,14	1														
8	distkm (ln)	6,85	0,61	-0,4	0,17	0,07	0,17	0,22	0,06	-0,17	1													
9	limitrop (inv)	0,76	0,43	-0,29	0,38	0,17	-0,05	0,08	0,11	-0,05	0,58	1												
10	ecorisk	2,12	3,2	-0,17	-0,05	-0,09	0,06	-0,09	0,04	-0,4	-0,03	0,05	1											
11	GNPC	1,85	2,41	-0,3	-0,04	-0,07	0,32	0,03	-0,14	-0,55	0,29	0,14	0,2	1										
12	HDI	1,79	2,64	-0,3	-0,01	-0,16	0,11	0,01	-0,05	-0,52	0,22	0,09	0,44	0,42	1									
13	openness	2,51	3,22	0,02	-0,07	0,21	-0,04	0,02	0,01	0,18	-0,08	0,06	-0,16	-0,05	-0,14	1								
14	trade	2,52	3,2	0,03	-0,07	0,2	-0,07	0,03	0,01	0,19	-0,08	0,06	-0,17	-0,06	-0,13	0,91	1							
15	NEB	1,45	1,73	-0,39	0,06	-0,1	0,17	0,09	0,05	-0,31	0,42	0,17	-0,11	0,31	0,24	-0,2	-0,2	1						
16	biopatent	1,89	3,18	-0,22	0,11	-0,13	0,1	0,03	0,02	-0,15	0,12	0,11	-0,03	0,3	0,02	-0,14	-0,16	0,39	1					
17	GERD	2,17	2,91	-0,09	-0,06	-0,03	0,21	0,17	-0,01	0,11	0,2	0,04	-0,16	0,1	-0,04	-0,05	-0,06	0,27	-0,08	1				
18	NCI	2,14	1,76	-0,16	-0,02	-0,11	0,32	0,38	0,12	0,08	0,3	0,04	-0,09	0,02	0,14	-0,22	-0,21	0,3	-0,08	0,52	1			
19	TAI	1,52	2,15	-0,11	0,04	-0,09	0,22	0,39	0,09	0,19	0,36	0,18	-0,18	-0,08	-0,07	-0,16	-0,14	0,26	-0,14	0,56	0,75	1		
20	expPCRD	2,14	2,65	-0,13	0,13	0,08	-0,06	-0,11	0,17	-0,12	-0,04	0,02	0,28	0	0,13	-0,07	-0,08	0,14	-0,06	-0,23	-0,16	-0,16	1	
21	expEureka	2,14	2,48	-0,12	-0,03	0,04	0,07	0,02	-0,1	-0,02	0,1	0,11	-0,1	0,24	0,33	0,02	0,03	0,18	-0,03	-0,1	0,05	-0,06	0,31	1
22	expACRD	2,14	3,42	0,22	-0,04	0,02	-0,16	-0,13	0,18	0,09	-0,15	-0,09	0,09	-0,14	0,08	-0,08	-0,07	-0,08	-0,16	-0,15	-0,1	-0,15	0,52	0,54

The values in bold are significant at α=0.05.

The statistical treatment of the data used in the study

In order to reduce to a minimum the problems caused by collinearity in the explanatory variables, a few precautions were taken prior to estimating the regression coefficients (Evrard *et al.,* 2003). The data were first synthesised in a phase involving the reduction of the variables whose results are summarised in **Annex C**, by applying Principal Components Analysis (PCA) with VARIMAX rotation on each of the study concepts. Following this, the constructs extracted from the procedure were integrated into three regression models which first only

concern explanatory concepts (model 1) and then integrate control variables in the regression (model 2) and finally correspond to the optimised regression in the sense of adjusted R2, which measures the quality of adjustment of the estimations of the regression equation.
The variable reduction stage led us to make a small number of adjustments. Specifically,
where economic distance is concerned, when PCA is applied to the whole range of variables two main axes are isolated. The first one combines the variables openness and trade and thus concerns the only aspects related to international economic relations between the countries in which the partners are operating, while the second factor, which is strongly correlated with the three other variables of economic distance but also, negatively, to the variable comember, relates more to the internal dimension of the economy. As a consequence, the concept of economic distance was split into two sub-concepts: DistEcoExt and DistEcoInt.
This concept thus seems to take into account the membership to the same economic area, a variable that was initially selected to operationalise administrative distance.
Similarly, with regard to the variables linked to technological distance, two sub-concepts emerged from the PCA process: one linked to the general level of technology in the partners' countries (DistTechG) and the other reflecting the separation between the allied entities in the more specific terms of their degree of maturity or development in biotechnology (DistTechB). Lastly, in light of the inadequacy of the two-by-two correlations between intellectual property rights protection (IPR) and the other variables relating to administrative distance, it was decided that this variable would be selected directly for the regressions without including it in the concept to which it was initially attached (cf. **Table 3**).
To sum up, seven synthetic concepts (DistCult, DistAdm, DistGeo, DistEcoInt, DistEcoExt, DistTechG and DistTechB) emerging from the PCA, and one initial variable (DistIPR) therefore make up the eight explanatory constructs selected for the three regression models whose general and detailed (for the three collaborative contexts) results are presented in **table 5**.

The results of the regression models are summarised in **table 4**, which shows that the coefficients have the same sense as indicated in the bivariate correlations. Considering the number of explanatory variables of the study, the obtained adjusted determination coefficients (R^2) are relatively satisfactory because they range, in the case of total co-participations in different projects, between 0,39 and 0,44. Nonetheless, and even if they are coherent with previous results, the estimated coefficients also make it possible to emphasise several specific characteristics concerning the aggregated level of total co-participations to the agreements or in one of the three contexts examined separately. Concerning the level of co-participations in R&D projects in general, it seems that cultural distance is not one of the significant explanatory constructs of the regression models. Moreover, the estimations make it possible to show the essential role of technological distance specific to partners, which seems slightly superior to the general level of technology. In other terms, the degree of maturity of the biotechnology of countries where partners of an R&D cooperation are located seems to have a significant impact on the choice of a partner. Finally, the role of geographic distance appears to be less important in the regression models as compared to the simple two-by-two correlations, because the estimated coefficients, even if they are significant and negative, do not make it possible to deem this dimension as having priority. Thus, and even though they are imperfectly unstable, estimated regression models (1, 2 and opti-mised) on the co-participations of the three types of projects in our sample give an initial idea of the most significant dimensions when European biotechnology companies conclude partnerships with an international dimension. Independently of the estimation of the absolute value of coefficients, all these models (cf. **Table 4**) show that distances linked to culture and the

external economy of partners are not significantly linked to the intensity of co-participations in general.

Table 4 – Results of regressions

	Agreements (n=1 502)			**EU Framework programmes** (n=737)			**Eureka projects** (n=163)			**Non-framework agreements Non-framework agreements** (n=602)		
	model 1	model 2	mod. optim	model 1	model 2	mod. optim	model 1	model 2	mod. optim	model 1	model 2	mod. optim
DistCult	-0,098	-0,049	-	-0,110	-0,062	-	-0,024	-0,075	-	-0,218	-0,224	-0,196
	(-1,132)	(-0,567)		(-1,290)	(-0,723)		(-0,24)	(-0,756)		(-2,319**)	(-2,278**)	(-2,155**)
DistIPR	-0,223	-0,203	-0,196	-0,227	-0,207	-0,2	-0,176	-0,156	-0,148	-0,157	-0,166	-0,179
	(-2,772***)	(-2,580**)	(-2,579**)	(-2,854***)	(-2,662***)	(-2,660***)	(-1,929*)	(-1,732*)	(-1,7*)	(-1,800*)	(-1,864*)	(-2,098**)
DistAdm	0,217	0,219	0,211	0,224	0,228	0,216	0,125	0,127	0,142	0,057	0,058	-
	(2,760***)	(2,866***)	(2,855***)	(2,888***)	(3,005***)	(2,962***)	(1,408)	(1,448)	(1,682*)	(0,669)	(0,669)	
DistGeo	-0,182	-0,17	-0,184	-0,161	-0,147	-0,166	-0,251	-0,252	-0,224	-0,224	-0,24	-0,229
	(-2,178**)	(-2,067**)	(-2,436**)	(-1,945*)	(-1,814*)	(-2,225**)	(-2,754***)	(-2,689***)	(-2,593**)	(-2,474**)	(-2,630***)	(-2,545**)
DistEcoI	-0,460	-0,422	-0,404	-0,479	-0,441	-0,421	-0,311	-0,271	-0,275	-0,248	-0,269	-0,246
	(-5,894***)	(-5,328***)		(-6,201***)	(-5,629***)	(-5,649***)	(-3,513***)	(-2,985***)	(-3,193***)	(-2,927***)	(-2,969***)	(-2,917***)
DistEcoE	0,02	0,009		0,017	0,008	-	0,055	0,039	-	-0,092	-0,089	-
	(-0,261)	(0,119)		(0,223)	(0,105)		(0,623)	(0,436)		(-1,082)	(-1,013)	
DistTechG	-0,238	-0,245		-0,238	-0,243	-0,232	-0,176	-0,189	-0,189	-0,352	-0,345	-0,353
	(-3,066***)	(-3,180***)		(-3,091***)	(-3,182***)	(-3,113***)	(-1,99**)	(-2,148**)	(-2,186**)	(-4,175***)	(-3,962***)	(-4,198***)
DistTecB	-0,271	-0,269		-0,27	-0,266	-0,261	-0,226	-0,233	-0,219	-0,175	-0,186	-0,178
	(-3,525***)	(-3,460***)		(-3,559***)	(-3,457***)	(-3,496***)	(2,595**)	(-2,618**)	(-2,529**)	(-2,101**)	(-2,120**)	(-2,142**)
PCRD	-	-0,225		-	-0,218	-0,225	-	-0,252	-0,229	-	0,096	-
		(-2,391**)			(-2,344**)	(-2,545**)		(-2,342**)	(-2,236**)		(-0,901)	
Eureka	-	0,051		-	0,045	-	-	0,058	-	-	-0,022	-
		(0,631)			(0,570)			(0,633)			(-0,245)	
ACRD	-	0,222		-	0,229	0,246	-	0,205	0,199	-	-0,075	-
		(2,381**)			(2,479**)	(2,768***)		(1,926*)	(-1,994**)		(-0,701)	
R^2	0,44	0,484		0,452	0,496	0,498	0,28	0,332	0,321	0,342	0,347	0,337
adjusted R^2	0,393	0,423		0,406	0,436	0,456	0,22	0,253	0,279	0,285	0,269	0,296
F	9,43(***)	7,93(***)		9,88(***)	8,305(***)	11,887(***)	4,84(***)	4,62(***)	5,79(***)	6,194(***)	4,53(***)	8,030(***)

*p<0,1 : * ; p<0,05 : ** ; p<0,01 : ****
The t-values of Student are indicated between brackets.
Calculations established for 105 couples.

The optimised model confirms the coefficients estimated in the previous regressions (models 1 and 2). It leads to a determination coefficient of 0.437, which is satisfactory (F=11.07, significant at α=1%) and superior to those obtained in the previous tests. It can be seen that the most significant dimensions of distance where R&D cooperation in the biotechnology sector is concerned are the following, in descending order of importance:

- Those linked to the domestic economy of the partners' countries (DistEcoInt)
- Those linked to the level of maturity in biotechnology in the economies in which the partners are operating (DistTechB)
- Those linked to the general level of technology in the countries where the partners are based (DistTechG)
- Those linked to the intellectual property rights legislation applicable to the partners (DistIPR)
- The geographic distance between the organisations associated under the c-operation agreement (DistGeo)

In addition, the three estimated models concerning the co-participations in the different forms of R&D cooperation show that administrative distance is not negatively linked to the propensity to cooperate: on the contrary, partner organisations seem to prefer diversity in this area. Thus, the optimised model, concerning the three types of agreements, supports **hypotheses H2 and H5** completely, **hypotheses H3 and H4** partially, and invalidates **hypothesis H1** relating to cultural distance (cf. **Table 4**). Finally, it also emphasises the significant role of the difference concerning the experience in terms of cooperation formed in the context of EU framework programmes and non-framework agreements, even if, in the latter case, the sign of the estimated coefficient (0.238***) shows that the organisations choose allies that do not have the same level of experience and knowledge to conclude new international agreements. More generally, this result confirms the role of the search for complementary resources in the choice of a partner for cooperation, which concerns knowledge (Shenkar and Li, 1999) as well as know-how. However, these general results need to be interpreted in the light of the estimations conducted for each of the different collaborative contexts examined. In fact, the calculations for the EU-framework programmes, Eureka projects or other R&D agreements which we have named nonframework agreements show several specific characteristics which need to be mentioned. This is also important because the sample of non-framework agreements is exempted from the eventual bias of the search for public subsidies on the choice of the partner. Thus, interpretation of global results needs to be carried out with caution and has to take into account the fact that participation in these European programmes can, to an extent that needs to be evaluated, force companies to select a partner, located in a certain country, which may not have been chosen in the context of a non-framework agreement without subsidies. In this type of situation, it is in fact possible to maintain that the choice of the country of the partner has the objective of optimising the benefits of public funds and/or to respond to an incentive of institutions providing subsidies, thus reducing the role of the different dimensions of distance examined in this research. **Table 5** indicates the results by briefly presenting the observed differences in comparison to the aggregated co-participations.

Table 5 – Results overview

Hypotheses	Results for all co-participations	Specific characteristics according to the context of the cooperation
H1: Cultural distance (C)	No significant relationship	Specific characteristics according to the context of the cooperation This dimension appears weakly but significantly linked to the propension of companies to conclude R&D agreements outside Eureka or EU-framework programmes (effect <0).
H2: Administrative distance (A) *Intellectual property rights*	Relationship<0	This aspect seems important whatever the collaborative context. It is nonetheless slightly more important in EU-framework programmes.
Legal and administrative situation	Relationship>0	Concerning aggregated co-participations, the administrative situation of countries where partners are operating appears to be significantly different. However, this administrative diversity does not exist in non-framework programmes and seems less important in Eureka projects.
H3: Geographic distance (G)	Relationship<0	The organisations choose in priority partners which are geographically close whatever the context considered.
H4: Economic distance (E) *Internal economy*	Relationship<0	Companies mainly collaborate with organisations operating in similar economic environments. This dimension of distance seems to have a significant impact on the conclusion of cooperative agreements and more specifically in EU-framework programmes.
External economy	No significant relationship	This dimension of distance does not seem to be linked to the conclusion of R&D cooperation, whatever the observed context.
H5: Technological distance (T) *General technological level*	Relationship<0	This dimension of distance seems particularly important in non-framework programmes.
Degree of maturity in biotechnology	Relationship<0	This aspect seems to influence the propension of firms to conclude international cooperative agreements and more specifically in the context of EU-framework programmes.

The analysis, which concerns R&D partnerships in biotechnology, shows that, except for non-framework agreements, none of the regression models tested shows a negative and significant relationship between cultural distance and the propensity to cooperate, despite the fact that this type of distance is presented as being of key importance by Ghemawat (2001), Parkhe (1991) and Simonin (1999). This result echoes that of Cabo (1997), who, in the context of Eureka projects in the medical field, had already highlighted the limited impact of the Hofstede dimensions on the intensity of inter-organisational cooperation. It seems interesting to note that for this dimension the differences between the three collaborative contexts appear to be particularly significant.

It thus seems that cultural distance perceived by partners is becoming weaker when the cooperation is supported, at least partially, by public institutions. In the contexts of Eureka projects and EU-framework programmes, cultural difference is not so widely perceived as an obstacle to the conclusion of cooperation agreements. More generally, our result fuels current controversy as to the impact of cultural distance and its measurement via the index developed by Kogut and Singh (1988).

Some authors even suggest that cultural distance might be conducive to cooperation on the grounds that it could be a source of complementarity (Yeheskel et al., 2001). In this sense, culture can be treated as one of the key resources for allied organisations whose combination may generate beneficial forms of complementarity. With this in mind, it should be remembered that researchers, irrespective of their countries of origin, form a community whose ramifications stretch around the planet. Indeed, this collective belonging to an extended scientific community of members of organisations involved in R&D cooperation agreements is such that it can encourage informal contacts and therefore to surmount cultural differences that keep partners apart. This tolerance for cultural diversity, which is obvious in our results concerning agreements concluded in Eureka projects and EU-framework programmes, needs to be verified in other industries, which are probably affected differently by this dimension of distance.

Concerning administrative distance, it seems important to note that relating to property rights, results indicate that a distance between allies would effectively be dissuasive to the establishment of cooperative links. It thus seems that the partners' national environment cannot only hinder or favour innovation according to the legal context developed for its appropriation (Porter and Stern, 2001), but can also moderate the intensity of R&D cooperation. This result is compatible with the work of Hagedoorn et al. (2005) who emphasise the importance of differences in terms of property rights for technological cooperation. The authors even conclude that 'international differences concerning the protection of property rights reflect significant differences concerning technological capacities of countries' (Hagedoorn et al., 2005, p. 183).

In the same way, and based on the appreciation of these rights developed by Ginarte and Park (1997), Allred and Park (2007) demonstrate that the level of protection in a given country is significantly linked to the level of innovation of that country. Concerning R&D agreements, differences in legislation concerning property rights seem to generate a higher degree of uncertainty concerning the outcome and appropriation of results of the collaboration and thus reduce any propensity to cooperate. Conversely, the different regression models suggest that European actors, far from preferring to cooperate with organisations with similar administrative and political environments, tend to favour diversity. While the choice of partners does not seem to depend on this dimension of distance, it cannot, nevertheless, be ruled out that this form of separation may influence spin-offs from the collaborative project or the way in which it unfolds. That being said, it is nevertheless true that the differences

are probably less significant in absolute terms (given that most of the countries concerned are EU Member States), but this outcome is no less surprising or difficult to interpret in the light of current knowledge with regard to administrative differences. It seems that it would be worthwhile to verify this result using a sample of agreements associating actors from outside of Europe, because the observed preference for administrative diversity may be linked to the strong proportion of agreements concluded by English, German and French organisations

in the analysed sample.

The hypothesis concerning geographic distance is confirmed by the analysed data, which highlights that the necessary face-to-face interactions involved in most joint R&D projects are made more difficult by geographic separation (Bélis-Bergouignan, 1997). It is obvious that firms working in the field of biotechnology have understood this well since the exchange of knowledge is evidently more often contemplated by them with a partner based nearby. The result obtained does, however,need to be put into perspective. This is so because the effects of geographic distance on the intensity of cooperation might be linked to the size of European biotechnology enterprises, which is often limited. In fact, it seems to be the case that all economic actors are not governed in the same way by the 'constraint' of physical or spatial proximity between allies. Where this point is concerned, SMEs seem to be more affected, whereas large corporations, given the scale of their resources, are in a position to replace it by means of artificial solutions (exchanges of personnel for example), recreating a form of geographic proximity that is lacking in reality. In particular, it would seem to be necessary to verify the extent to which the need for the local embedding of companies is dependent not only on their size but also on the industry to which the cooperating firms belong.

Our analysis also reveals that economic distance shapes the development of R&D cooperation agreements. This outcome, clearly highlighting the importance of economic and financial criteria in the definition of corporate relational strategies, is in line with that obtained by Cabo (1997), who observes that in the context of projects established under the Eureka label, there were fewer agreements between countries whose gross national products differed greatly. For example, where Ghemawat (2001) has already seen that differences in terms of the living standards of the populations of two nations were likely to create a distance which would be damaging to trade relations between them, we can add that such differences are also harmful to the establishment of cooperative R&D programmes in the biotechnology field. Conversely, aspects related to the external economy turn out to have no influence on either the intensity of relationships established between organisations or the form taken by the alliances (Hagedoorn *et al.,* 2005).

Lastly, our results confirm that technological distance represents an obstacle to the establishment of R&D cooperation. The idea of similarity between scientific environments recalls the notion of absorptive capacity developed in the work of Cohen and Levinthal (1989) and the more 'relative' concept formulated more recently by Lane and Lubatkin (1998). It is true that a certain degree of familiarity with a partner's technical and scientific knowledge is required to facilitate its comprehension, its transfer and, finally, its full absorption (Lane and Lubatkin, 1998). This proposal is confirmed at the micro-level of the organisation by Mowery *et al.* (1998), who observe that the choice of a partner will tend to focus on an organisation of similar technological competence.

On this point, the models tested above make it possible to extend these considerations to the national territories in which the allied organisations operate, which, if they are technologically close, can then be con-

sidered to favour the establishment of cooperative links. Similarly, our data confirms the conclusions reached by Allred and Park (2007) and Porter and Stern (2001). This means that national technological 'potential', which is similar to what Porter and Stern (2001) call the 'national innovative capacity', seems to act as an indicator for the scope, nature and characteristics of organisations' external knowledge, and when firms engage in R&D cooperation, it seems therefore that they prefer to opt for partners who resemble them in this regard.

In particular, European businesses prefer to engage with academic or industrial actors working in environments that are similar in terms of research and activity in biotechnology. This idea echoes the formulation of Cohen and Levinthal (1989) whereby the absorptive capacity of an organisation will depend both on its internal R&D effort and on the expenditure committed by other firms, as well as the level of knowledge present outside the industry in which it operates. It is worth noting that the result obtained in the domain of what we have called 'Biotech Europe' is in our view fairly symptomatic of ongoing changes in the biotechnology sector in the 'Old World', which seems today to be making up the ground lost in the past to the United States. In effect, it is likely that the manifest importance of technological criteria when choosing an R&D partner reflects deeper structural changes in the reasons that lead companies to enter into such agreements and testifies to the fact that technological cooperation motivated by access to extra skills is no longer exclusive to agreements signed with companies in North America (Owen-Smith *et al.,* 2002).

The statistical analysis confirms in this way that distance is a significant factor in the signing of international cooperation agreements in the R&D domain, at the very least where biotechnology is concerned. It highlights the relevance of the analytical framework proposed by Ghemawat 2001), demonstrating most notably that distance needs to be observed on the basis of its various component dimensions. In addition, the results support the notion of technological distance, absent from Ghemawat's initial model (2001), thus suggesting that this parameter (T) should be added to the CAGE model formulated by the author.

Our results also show the practical difficulty of isolating each of the component dimensions of distance by emphasising the various interactions that exist between them. They also raise the question of the appreciation of administrative distance in comparison to the more economic and legal aspects as well as its interpretation and call for additional research on this dimension.

More generally, our research highlights the importance of distance for the international development of companies. In fact, despite the undeniable effects of economic globalisation and regional integration, especially in Europe, it reveals that distance continues to influence firms' propensity to cooperate. In this sense, our results contribute to the debate on the role of distance for the international development of firms. In particular, they confirm studies conducted in international business, which emphasise that distance represents a significant obstacle to the international development of companies, and more specifically re-

search linked to the perspective of the Uppsala model (Johanson and Vahlne, 1977). In fact, distance can generate uncertainty (Delios and Henisz, 2000, 2003a and b) and create specific costs (Eden and Miller, 2004), and thus have a significant impact on the choice of investments made by companies. The in-depth analysis of the influence of different forms of distance suggests that the psychic distance perceived by companies for their international development, which is frequently tested by cultural distance, is part of a more complex reality.

It is thus possible that the other dimensions of distance, such as geographic, economic and technological distance, which are less studied in the literature, have a more significant impact on the psychic distance perceived by companies than cultural distance when companies decide to develop in international markets. It thus seems necessary to elaborate a theoretical model of internationalisation that also integrates other dimensions that are likely to influence the psychic distance perceived by companies. Our research suggests that the impact of cultural distance, which has been studied in numerous empirical investigations, is probably overestimated in comparison to other dimensions of distance. In this sense, it seems necessary to enrich the Uppsala model initially proposed by Johanson and Vahlne (1977) by considering the existence of different forms of distance which are likely to influence psychic distance as it is perceived by companies. In this perspective, the developments offered in this article help to provide the foundations for a new model of internationalisation which could be based on the Uppsala model and the analytical framework proposed by Ghemawat (2001).

In fact, our empirical investigations question work on 'born globals', which considers that distance does not represent a determining factor in the international expansion of companies because the latter immediately develop on the global market (Zucchella and Scabini, 2007). Even if many companies in biotechnology attempt to operate on the global market and are often considered as 'born globals', it seems that the different identified forms of distance continue to influence the psychic distance perceived by companies and thus their choice concerning internationalisation, at least in Europe. Finally, our study also contributes to research into the evaluation of risk and in particular country risk in the internationalisation process of companies by showing that the latter need to be evaluated not only in absolute terms but also in relative terms by considering the different dimensions of distance.

CONCLUSION

Driven by the globalisation of markets and competition, companies are led to build cooperative relationships with actors based in other countries. Once a company enters into a cooperation agreement, it is faced with the need to cope with the distance separating it from its partner's local environment. However, the effects of distance on the propensity of firms to cooperate have not been subject to a great deal of research, probably because of the difficulty of assessing the concept of distance. The analysis presented in this article contributes to a better knowledge of the impact of distance on the choice of partners in the context of R&D cooperation, while at the same time stressing its multidimensional character. It reveals that while distance has a general influence on the propensity of companies to cooperate, certain dimensions can be seen to be more significant than others. The empirical study conducted notably shows that administrative, geographic, economic and technological distances play a key role, whereas cultural distance does not seem to influence the choice of partners, at least in the biotechnology industry. The study conducted allows a more precise appreciation of the dominant criteria for choice when putting in place an international R&D collaboration.

It highlights the importance of environmental factors for understanding cooperative strategies adopted by companies (Christmann *et al.,* 1999). Given this, it is possible to identify several directions for future research. Firstly, given the mono-sectorial nature of this study, it seems necessary to conduct similar studies in several industries and notably in activities with a moderate or very limited level of technological content. Secondly, there is a need to look in more depth at the various dimensions of distance in order to identify the most relevant indicators. The analysis of the existence of a possible 'windfall effect' when subsidised agreements are signed, possibly reflected in lesser sensitivity to certain types of distance, seems to be an interesting way forward. In fact, the role of such subsidies can have an influence on the reasons firms give when justifying their engagement in an alliance that is then generally focused more on sharing the costs and risks of the project than on seeking complementarity.

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Appendix A – List of countries considered and number of projects examined in the study

Europe Biotech		
Austria (79)	Finland (102)	Italy (316)
Belgium (265)	France (643)	Netherlands (492)
Germany (798)	United Kingdom (753)	Norway (73)
Denmark (245)	Ireland (108)	Switzerland (203)
Spain (299)	Island (14)	Sweden (292)

Appendix B – Indicator components

Indicator	Components
Intellectual Property Rights (IPR)	- Scope of patent protection (invention patentability) - Duration of protection - Methods available in country for the enforcement of rights - International conventions signed - Absence of restriction on rights and legal means for enforcement of IPR
Legal structure (legal)	- Independence of the judicial system - Impartiality of the judiciary system - Protection and enforcement of property rights - Role and involvement of the military in the legislative system and political processes - System integrity - Contract performance and application - Regulations and control of transfers of ownership
Regulation (regul)	- Credit market regulation: bank ownership, terms of credit, interest rates and credit control - Labour market regulation: minimum wage, regulatory controls on employee termination and hiring, unemployment benefits - Business and trade regulation: unregulated prices, conditions for forming new companies, taxation, tax system and bureaucracy
Political risk (polrisk)	- Stability of government - Social and economic conditions - Conditions for investment - Internal conflicts and external conflicts - Corruption - Influence of the military - Political influence of religion - Legislative system - Pressure from ethnic groups - Democratic accountability - Bureaucracy and stability of institutions
Economic risk (ecorisk)	- Per capita GDP - Real growth in GDP - Inflation rate - Budget balance (% GDP) - Current account balance (% GDP)
Level of development (HDI)	- Life expectancy and health system - Access to learning and knowledge (school enrolment and literacy) - Standard of living for general population
National capacity of innovation (NCI)	- Proportion of scientists, engineers and technicians within the workforce - Public politics concerning innovation - Favorable environment for innovation in clusters - Index of infrastructure reflecting the quality of scientific research institutes and the importance and vitality of links established in the field of innovation
Technological accomplishments (TAI)	- Level of technological creation - Level of dissemination of recent innovations - Level of dissemination of older innovations - Technological skill base

Appendix C –Data reduction

Concepts	Dist Adm	Dist Geo	Dist EcoExt	Dist EcoInt	Dist TechG	Dist TechB	Description of sample**	
Alpha de Cronbach	0,755	0,735	0,97	0,692	0,826	0,679	Average of individual scores	Standard error
Variables	(corrélations	with	factors*)					
IPR	- 0,114						4,22	0,45
polrisk	**0,835**						80,87	3,72
legal	**0,874**						8,69	0,71
regul	**0,715**						6,78	0,70
comember	0,134			**-0,811**			-	-
distkm		**0,745**					-	-
limitrop		**0,931**		**0,607**			-	-
ecorisk				**0,687**			39,49	2,15
GNPC (1 000 € PPA/ hab)							23,22	2,87
HDI				**0,823**			0,94	0,01
openness			**0,975**				39,41	15,91
trade			**0,976**				41,32	18,92
NEB (/MH)					0,377	**0,614**	8,20	6,29
Biopatent (/MH)					-0,264	**0,763**	8,53	6,35
GERD					**0,869**	0,104	2,00	0,679
NCI					**0,832**	-0,027	25,90	1,48
TAI					**0,887**	-0,02	0,58	0,076

** Only correlations higher than 0.5 are presented. The Cronbach's alpha calculated for administrative distance only takes into account the three variables that are significantly related to this concept (polrik, legal et regul); the variable comember is integrated into economic distance and the variable IPR is kept apart from this concept.*

*** The description provided for the sample corresponds to the measures found on the level of each country, therefore the information cannot be provided for the variables comember, distkm and limitrop. The statistics concerning these distances appear in Table 3.*