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A STUDY OF SCIENCE-INDUSTRY COLLABORATIVE PATTERNS
IN A LARGE EUROPEAN UNIVERSITY

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Abstract.

This paper analyses the modalities according to which a large European university collaborates with firms by exploring its relational portfolio. We address this issue by exploiting a database listing more than 1000 firms having collaborated with the University Louis Pasteur between 1990 and 2002. First, using multi-correspondence analysis, we derive a four-classes typology of collaborative behaviours, each of them presenting a strong internal coherence. We obtain four distinct collaboration patterns, for which the frequency of interactions and the exclusive vs. open character of the relationships are discriminating features. Second, using a multinomial logit estimation, we show how this diversity is connected to some individual attributes of the firms: size, legal status, industrial sector and geographic distance from the public partner.

Keywords. Science-industry collaborations; Typology; Industrial collaboration patterns;

JEL Classification. L21; L31; O32

1. Introduction

Since the beginning of the 80's, an intensification of the practices of collaboration between universities and firms has been observed, these collaborations taking very heterogenous forms and channels: purely informal exchanges of knowledge, co-publications, co-invention of patents, research contracts, researchers' mobility, etc. The phenomenon raised considerable scholars' attention (see for example Hall, Link & Scott, 2000, Cohen et alii, 1998, Jankowski, 1999, Godin & Gingras, 2000), probably because it conveys major policy implications in terms of innovation performance.

Indeed, the literature about university-industry collaborations is part of the broader set of – mainly empirical - analysis concerning the relationships between Academia and the industrial sphere[1]. Within a climate of rising questions concerning the economic relevance of scientific knowledge for Society (Gibbons et alii, 1994), some scholars have tried to assess and have found a positive impact of Science upon economic performance and/or firms' innovativeness (cf. Adams, 1990, Jaffe, 1989, Acs et alii, 1992). Other authors, on the ground of large surveys of firms and/or universities, have examined the role of Public research organizations (PROs), including universities, as a source of knowledge for innovating companies (Arundel & Geuna, 2004, Klevorick et alii, 1995, Cohen, Nelson & Walsh, 2002, Laursen & Salter, 2004), leading to the idea that PROs are significant contributors to industrial innovations, although less important than suppliers or clients of the interviewed companies.

Beside this positive relationship from science to industry focussing on the transfer of scientific knowkedge to firms and its social benefit, the trend toward "commercialization of science" raises serious worry concerning possible damages on the norms of Open Science, as defined by Merton (1973)[2]. The collective organization of Science might thus suffer from restrictions in knowledge disclosure (less publications), as well as modifications in research agenda (oriented towards more applied research). Here again surveys, especially university surveys, provide interesting information about eventual changes in scientists' behaviors and opinions (see for instance Cohen et alii, 1998, Lee, 1998, Blumenthal et alii, 1997). While most of these empirical analysis tend to support the presence of information withholding

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[1] For a critical review about the benefits of public research, see Salter & Martin (2001).
[2] See Dasgupta & David (1994) for comprehensive theoretical developments about the New Economic of Science.

behaviours, clear evidence concerning major changes in research agendas or decrease in research productivity seems to be absent. Thus the debate on the negative consequences of close links with industry upon Open Science efficiency remains open.

Studying the impact of Science upon economic performance and/or the reverse influence of industrial constraints upon university culture and efficiency fall well beyond the scope of the present paper, which rather aims at analysing the diversity of university-industry collaborations. But recallling these central issues of the literature is necessary to apprehend properly the strategic importance and the political implications of the collaborations between firms and universities. Among the broad set of science-industry linkages, the university-industry collaborations present a distinctive property: they consist in two-ways exchanges of knowledge by contrast to unilateral transfers from university toward industry (Meyer-Krahmer & Schmoch, 1998). As such, they are privileged vehicles for interactive learning and innovation. However they potentially undergo higher risks of tensions and conflicts. Like Cassier (1997), we contend that they are better considered as *loci* of compromises and hybridization of the institutional rules governing public science and private research (respectively: disclosure and non appropriability versus secrecy and appropriability).

Whereas the motives, obstacles and impacts of university-industry collaborations are rather well documented through a growing number of empirical analysis based on firms' and/or universities' surveys, the great diversity of the forms of public/private collaborations still remains poorly analyzed. Exceptions are Cassier (1997), Joly & Mangematin (1996), and Carayol (2003). However different cooperative modalities may well have different implications in terms of knowledge exchanges, innovation potential and cultural hybridization...How do companies cooperate with universities? Is it possible to identify different types of collaborative behaviours (or collaborative patterns)? If yes, do they correspond to specific firms' characteristics?

We attempt to address these questions by exploring the portfolio of industrial relationships of a large university. We base ourselves on a unique and original database about the research activity of a large, diversified and well-ranked European University : University Louis Pasteur (ULP) in Strasbourg, Widely acknowledged for its academic excellence, ULP covers almost all scientific fields (if we except Law, Art and Humanities), and has a strong and long-standing inclination toward fundamental resarch. The database gathers information about

inputs and outputs of the university (human resources and laboratories, publications and patents) and about the research contracts with the private sector. The sample we use here comprises more than 1,000 firms having collaborated at least once with ULP between 1990 and 2002. In a first stage, a typology of collaborations patterns of ULP's industrial partners is derived, by the means of a multi-correspondence analysis followed by an ascendant hierarchical classification. We show that the frequency/variety of interactions on the one hand, and the number of participants (closed and dyadic relationship vs. open and multilateral partnership) on the other hand, are discriminating features of the various patterns we obtain. In a second stage of the analysis, we attempt to highlight this diversity according to the individual attributes of firms, using a multinomial logit estimation.

The paper is organized as follows. The next section introduces key concepts on science-industry collaborations based on existing literature. The third section provides information on the data and some descriptive statistics. The fourth section is dedicated to the typology of collaborative patterns (or profiles) of ULP's industrial partners. The fifth section presents the results of the econometric multinomial logit model, estimated on the basis of the classes to which the private partners belong. In the last section, we shall propose a synthesis of the results and some extensions for further research.

2. Brief overview of the literature, main concepts and hypotheses

2.1 From a variety of interactions to diverse collaborative patterns

Considering the notion of collaboration at the heart of the present contribution, it is necessary to define it more precisely before going any further into the analysis. If we accept the usual meaning of "collaborating", i.e. "working together in order to reach common goal(s)", it seems to us that talking about university-industry collaboration implies a clear move from a unilateral, knowledge sourcing perspective to a much more reciprocal, mutual exchange perspective, in order to reach the ultimate goal of creating new knowledge[3].
A growing part of the literature about university-industry relationships highlights the diversity of the different channels of interaction linking PROs to companies, trying to compare their relative importance (see for instance Faulkner & Senker, 1994, Cohen et alii, 1998, Cohen et

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[3] Using an organizational learning perspective, Cyert & Goodman (1997) provide very interesting insights and recommendations on the best way to create effective university-industry alliances.

alii, 2002, Schartinger et alii, 2002, Meyer-Krahmer & Schmoch, 1998, Arundel & Geuna, 2004). It is worth mentioning here that the word "interactions" is a rather fuzzy concept that encompasses the mono-directional sourcing of scientific knowledge by companies (reading publications, surveying academic patents, hiring scientists,…) as well as more bi-directional knowledge exchanges like informal contacts, joint research contracts, co-publications and other forms of effective collaboration.

Like Meyer-Krahmer & Schmoch (1998) we consider that effective collaborative relationships require bi-directional channels of interaction. It seems to us that mutual exchanges represent also a precondition for knowledge creation. And like Schartinger et alii (2002) we focus on interactions that suppose face to face contacts and a certain degree of formalisation. More precisely, among the different channels of interaction which are relevant for our purpose, we exploit information concerning (cf. section 3 for a detailed presentation of the data):

- co-authering of scientific articles by public and private researchers: here co-publications are not considered as cooperative outputs, but rather as tangible signs of effective cooperation. More precisely co-authoring takes place at the level of individuals (not institutions) et usually requires informal inter-personal contacts.

- co-invention by private and public resarchers leading to a patent; like in the previous case, co-invented patents are mainly seen as codified, visible sign of - eventually more informal – collaboration;

- contractual arrangements between public research and industrial institutions, with a sharp distinction between "spontaneous", non publicly subsidized agreements[4] (which we will call "private contracts" in the subsequent parts of this paper), and…

- …E.U. sponsored agreements, that is to say subsidized collaborative projects signed in one of the Community's R&D Framework Programmes.

The reason behind this distinction has to do with the hypothesis that E.U. agreements are somewhat less governed by secrecy rules and appropriability problems, inasmuch as they are multi-partners, obey to information disclosure rules[5] and often concern pre-competitive

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[4] Unfortunately our data do not make it possible to distinguish between contract reseach and joint research project.
[5] Information concerning the content, the objective and the partners of a given E.U. project is public information, available in the Cordis database. For a theoretical analysis concerning the distinciton between EU sponsored and private, spontaneous alliances, see Matt & Wolff (2004).

research[6]. By contrast, "private contracts" are often dyadic (i.e. they involve only two partners; cf. also the notion of "bilateral" contract in the literature), which makes it possible to better preserve the confidentiality and the appropriability of the research outcomes (Cassier, 1997).

Of course we recognize that the four types of channels taken into consideration here are only a subset of the whole set of collaborative links. They were chosen because they represent measurable signals of formal but also informal forms of collaborations between universities and firms[7]. An additional, methodological aspect of our contribution deserves consideration : contrarily to most of the empirical analysis in the literature, we do not analyze the channels separately, but we explore their (possible) combinations.

In this paper our main goal is to address the diversity of university-industry collaboration practices. But we contend that a given collaboration project cannot be reduced to one given channel. A collaboration may well use several channels simultaneously. Comparing the relative importance of the individual channels might thus be misleading. Of course this statement is even more true if we consider a collaborative relationship as a whole, instead of a given project (a collaborative relationship covers a longer time horizon, taking all projects into account).

This is the reason why we use the four channels mentionned above as elementary bricks to build profiles of industrial partners. More precisely, we observe the type(s) of channels, their frequency and the way they combine for a given industrial partner of University Louis Pasteur. Then we used data analysis techniques to derive a typology of collaborative patterns, or, more precisely, a typology of collaborative profiles of ULP's private partners.

Focussing on the literature specifically devoted to science-industry alliances, it might be noted that very few authors adress explicitly the internal diversity of such strategies. Most analyses, probably because they use the data obtained through non dedicated (innovation) surveys, deal with university-industry collaborations as if the latter were belonging to a single and homogeneous category. Notable exceptions are Carayol (2003) and Joly & Mangematin (1996).

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[6] Caloguirou et alii (2001, in their analysis of university-industry cooperation in the context of European Framework Programmes, find that the number of partners in a project is higher in case of academic participation. They explain it by the characteristics of university research : basic/generic and less appropriable.

[7] This does not mean that we collected all informal collaborations. We missed the pure informal collaborations with no tangible co-output.

By analysing qualitative data of 46 european collaborations in IT and Biotech/pharma, together with the main characteristics of both types of partners, the first author identifies five types of collaborations, depending on their degree of risk, novelty and basicness of research as well as on the number of partners (from bilateral research to networked research). Dealing with 182 research contracts of a large research organization (the French INRA, specialized in agronomy), Joly & Mangematin were able to characterize 3 relational logics : (i) a proximity logic where collaborations aim at testing a given hypothesis to generate private benefits, are based on trust, imply exchange of tacit, specific knowledge and tend to lead to new contracts ; (ii) a club logic where collaborations aim at producing a technical referent interesting several firms (social benefit), do not require a lot of trust but the exchange of codified and standardized knowledge; (iii) a market logic where collaborations aim at gaining expertise to relieve a scientific bottleneck (private benefit), require reputation (not trust), imply the exchange of codified and specific knowledge and never lead to contract renewal.

The rest of the literature considers university-industry collaborations as a single category. It aims basically at explaining the propensity of particular firms to collaborate with universities (Fontana et alii, 2006, Mohnen & Hoareau, 2003), the motivations for firms or universities to form public-private alliances (Caloghirou et alii, 2001, Lee, 2000, Miotti & Sachwald, 2003, Saez et alii, 2002), or the obstacles and success factors of such collaborations (Hall et alii, 2000, 2001),

2.2 Explaining the diversity of university-industry collaboration patterns: the role of sectoral membership, geographical proximity and size/status of the firm

Keeping in mind that the present contribution explores the diversity – and provides a typology- of the collaboration profiles of the industrial partners of a big French university, an important question remains: what factors explain the diversity of observed collaborative profiles ? It is tempting to look for an answer (even though it is only a partial answer) in the specific, independant features of the partner companies themselves, for instance their size, status, activity, innovativeness,…

Although the literature about university-industry collaborations never raises the issue of wether the specific features of industrial partners (of a given university) explain the diverse collaborative patterns (linking them to that university), several papers analyse the firm's characterisitics that influence the propensity to cooperate with a PRO, thus providing useful indication about the characteristics that could be the most relevant for our purpose. To

enumerate them briefly, these characteristics are : the size of the firm, its status (headquarter or subsidiary), its sectoral membership, its innovativeness (measured by the level of R&D expenditure), and its geographical proximity with university (location in the same region, country,…).

Trying to identify which types of companies have a greater propensity to cooperate with universities, Mohnen & Hoareau (2003) find, among other characteristics, that companies collaborating in innovation with PROs have generally a big size (they also hold more patents, or are firms receiving government support to innovate). The result concerning the size is widely supported by recent empirical investigations about university-industry interactions (Cohen et alii, 2002, Arundel et Geuna, 2004, Laursen & Salter, 2004, Fontana et alii, 2006) on the one hand, and about R&D collaboration in general (Tether, 2002, Fritsch and Lukas, 2001), on the other hand. Nevertheless there is also some indication that start up have a higher probability to benefit from public research (Cohen et alii, 2002).

As far as the sectoral membership of companies having close links with university is concerned, the leading importance of hightech sectors and especially the biotechnology or pharmaceutical industry is often emphasized and rather well documented (Cohen et alii, 2002, Meyer-Krahmer & Schmoch, 1998. See also Dalpé 2003 for an overview). Nevertheless, Schartinger et alii (2002), taking into account a wide range of university-industry linkages in the case of Austria, call into question the idea that the intensity of knowledge interaction follows a simple sectoral pattern (like: "hightech sectors having a high level of interactions versus lowtech sectors having weak interactions). It seems that sectoral patterns of interactions are much more complex than is commonly admitted.

Turning now to the geographical proximity factor and its influence on university-industry relationships, the results seem to vary considerably across empirical studies. Nevertheless, following Arundel & Geuna (2004) or Mansfield & Lee (1996) it might be suggested that geographical distance matters, especially at the national level. It can also be noted that, according to the former, this domestic preference does not hold for pharmaceuticals.

To what extent do the partners of our French University fit the picture that we have just described above? The next part of the paper sketches a – rough - answer to this question and more generally describes our data and variables.

3. Data and variables

3.1 The data

The university under analysis is the University Louis Pasteur (ULP), a French scientific university based in Strasbourg (Alsace region in the North East of France). This university is internationally acknowledged for its academic excellence, and was in 2005 one of the four French universities ranked in the top 100 of the most performing universities in the world (ranking of the University of Shanghai[8]). On average this university trains about 18 000 students and employs about 1500 researchers grouped in more than 70 units of research in mathematics, physics, chemistry, earth and universe sciences, engineering sciences and social sciences[9]. Nevertheless, ULP is widely acknowledged for its specialization in chemistry and life sciences.

In our analysis of the private partners of this university, we use a large database (more accurately a set of several databases) about the characteristics of public research at ULP. This database gives an account of the university's composition and its scientific activities. It gathers information about inputs of the search process (human resources of the university), (such as publications and patents) and about its research contracts with the private sector ("private" contracts and E.U. sponsored research contracts). More precisely information is organized and centralized on the ground of the list of the 1805 permanent researchers and 105 research units of the university. These two databases come from information contained in official documents, produced by each ULP's lab in the specific, French context of four-year contractual affiliation rounds ("contrats quadriennaux")[10].

Concerning the outputs of research, we collected information about all the publications cited in the Science Citation Index or Social Science Citation Index (bibliographic databases produced by ISI), published between 1990 and 2002 by at least one researcher mentionned in the "permanent researchers' database"[11]. In parallel, we identified all the 841 patents (French, European or American) invented by at least one researcher mentionned in the same database. We completed the data by collecting all the 4495 research contracts signed, between 1990 and 2002, by one of the ULP's laboratories, thanks to the technology transfer offices of the university (ULP-industry) and of the CNRS. This "contract database" provides a few

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[8] ULP was class as the 92nd rank : http://ed.sjtu.edu.cn/ranking.htm
[9] The half of theses units of research are associated to the CNRS.
[10] Each lab produces a document summarizing its research activity and its composition for the last four years, as well as a forecast of its research activity for the four next years.
[11] We have collect 43241publications which correspond to 23215 different article if we deleted the article publish by different ULP researchers.

information about the contracts themselves, the name of the different partners (firms and public institutions), including the contracts executed in the frame of European Programmes.

Finally, the last step was the building of the list of the private partners of the university. To achieve this, we considered the industrial partners that had collaborated with ULP through a "private" (in the sense of non-subsidized) research contract, a European contract, a co-publication and/or the ownership of a patent invented by a researcher of the university. This process resulted in a list of 1151 firms. For each firm we search for complementary information in the *Dun & Bradstreet Who Owns Whom* database, more precisely: the company's geographic location, its sector of activity, its size and its ownership status (independent vs. subsidiary). We finally remove from our analysis 131 firms, for which we missed information either on the location, on the industry or the size/ownership status .

To summarize, the empirical analysis presented here is based on a list of 1020 firms which have collaborated with ULP between 1990 and 2002 through (at least) one of the following channels: a "private" (non subsidized) research contract, a E.U. contract, a co-publication and/or a co-invention leading to a patent. Before coming to the different channels of collaborations which link ULP to these firms, it interesting to give a quick overview of the characteristics and attributes of the latter, in terms of location, sector, and size/status.

3.2 The variables

Seven different variables have been taken into account in our study of the collaborations between ULP and its private partners. These variables can be gathered in two groups: the different types of collaborative channels (or links) and the degree of exclusiveness of the relationship. In the first group, each variable concerns a given type of collaborative channel:

− *CONTRACTS*: number of "private" research contracts signed between the private partner and any research unit of ULP between 1988 and 2002. In fact, as be explained further, this "number" can take 3 modalities: zero, one and more than one.

− *EUR_CONTRACTS:* number of contracts realized in the framework of a European research programme, involving the private partner and a research unit of ULP between 1988 and 2002.

− *PUBLI:* number of publications co-authored by a member of the firm and a researcher of ULP (employed by ULP between 1996 and 2000), with a publication date between 1992 and 2002. It can be noted that a publication written by two or more researchers of the university is counted only once in our analysis.

– **PATENT**: number of patents owned by the firm between 1984 and 2001, and invented by at least one ULP researcher. As for the publications, a patent co-invented by two or more researchers of the university is counted only once in our analysis.

As explained in the precedent paragraphs, we considered patents and publications as a signal of a link between ULP and firms and not only as an output of a precedent research contract. To confirm this hypothesis, we could observe in the following table that only 47 firms (5%) have owned a minimum of one patent and have participated to a research contract (including European contract). We could also note that 302 (29%) firms have published a minimum of one article without participating to a research contract (including European contract).

Table 1. **: Number of firms having patent or publication and contract or European research contract**

	Patent				Publications				
Contract	Contract/patent	0	1	>1	total	Contract/publi	0	1	>1	total
	0	470	241	226	937	0	193	225	183	601
	1	20		11	31	1	200	15	29	244
	>1	19	7	26	52	>1	116	8	51	175
	total	509	248	263	1020	total	509	248	263	1020
European contracts	eur/patent	0	1	>1	total	eur/publi	0	1	>1	total
	0	752	129	56	937	0	433	120	48	601
	1	29		2	31	1	239	5		244
	>1	51	1		52	>1	160	5	10	175
	total	832	130	58	1020	total	832	130	58	1020

The second group of variables does not correspond to specific types of links between the firms and the university, but it concerns any type of link with a given partner. Based on the number and on the nature of participants in a collaborative link, the variables are designed to apprehend the degree of exclusiveness (vs. openness) of the relationships between ULP and a given partner. The basic idea is to distinguish dyadic relationships from those including other universities or industrials. To build this set of variables we procede in two steps.

First, each link, whatever its type (contract, co-patent or co-publications) is defined as dyadic if <u>only</u> ULP and the private partner considered are involved. A dyadic link vehicles a high level of exclusiveness. In the case of non dyadic link, the link is further characterized as "industrial" if (at least) another private partner is included in the collaboration (in addition to the reference partner); otherwise the link is named "university". Thus "University" means that there is no other industrial partner, but that there is (at least) another university who collaborates with ULP and the reference private partner. An "industrial" link (as defined

above) conveys a very high level of openness (it requires tolerance for a potential competitor), whereas a "university" link conveys an intermediary level of openness.

In a second step, we count the number of dyadic, industrial or university links for each industrial partner, and we obtain the three following complementary variables:

- *DYADIC*: number of links (contracts including European contracts, publications or patents) which concern exclusively ULP and the private partner.

- *INDUSTRIAL*: number of links which concern at least a second private partner (in addition to the university and the reference firm).

- *UNIVERSITY:* number of links concerning at least another academic partner, and no other private partner (in addition to the university and the reference firm).

After this presentation of the different variables taken into account in the analysis, we still have to explain the way of counting them. Indeed, if we want to analyse the differences in collaboration practices, it makes no sense to compare the accurate number of patents owned by a private partner with the number of contracts or the number of publications. For this reason, and also for technical reasons (namely: assuring good conditions concerning the initial population for implementing multiple correspondence analysis), it was decided to dichotomize each variable according to 3 modalities: zero links, only one link and more than one link. Indeed in Table 2 we can note that there is a rather well balanced repartition of each variable in these three modalities.

3.3. Descriptive statistics

We have also represented in table 2, the different variables relative to the characteristics of the firms: localization, sector of activity and size. In order to complete the description of these characteristics, we have computed in table 3, the correlation between the variable of link between the firms and ULP (contract, European contract, patent and publications) and these variables relative to the general characteristics of the firms (sector of activity, localization, and size).

As showed in the second half of Table 2, the majority of the partners of ULP are French private firms, often located in the central region around Paris (22% of the total number of partners) and less in the Alsace region (15%). We find also foreign companies (i.e. located abroad), in majority German (10%) or American (12%). To complete this description we could not in the table 3, that Alsatian and French firms are more used to participated to

research contract than to European research contracts or publications. At the opposite, international firm are used (by definition of this modality of collaboration) to be included in European research contract, but also to have activity of patenting and publishing.

We can also observe in Table 1 that ULP researchers collaborate mainly with firms specialized in the pharmaceutical industry (32% of the total number of partner) and in the chemical one (19% of the total number of partner). In these two sectors of activities (and more particularly in the case of pharmacy), firms have tendency to patent and publish and not to make some contracts (even European contracts). Concerning the others sectors of activity, we could note in table 3, that for all the others sectors, firms are used to participate only punctually to research contract activities and not used to patent or publish.

Concerning the size of theses firms, we distinguish the subsidiaries of large groups (more than 10000 employees), the subsidiaries of small groups (less than 10000 employees) the independent firms (from less than 50 to more than 10000 employees). More than half of ULP's partners are subsidiaries of small and large industrial groups. Concerning the link between the size of the firms and their links with ULP, we could note that the practice of patenting and made European contract seems not link with the size of the firm. Concerning the participation to research contract we could note that small firm (independent > 50 employees) are more used to make (punctual) research contract than bigger ones (independent 500-10 000) and reciprocally they are not used to patent and publish.

So we have seen in the precedent paragraph, that some characteristics of the firms are links to form of links with ULP. In order to complete this first descriptive analysis, we will try, in the following paragraph to determine some pattern of collaboration of the firms with ULP and after to link these patterns of collaboration with the characteristics of the firms.

Table 2. **Presentation of the variables**

Variable	Modality	Number of firms	%
EUR_CONTRACTS : Number of contracts realized in the frame of European programmes	Eur0 : 0 contracts	832	81,6%
	Eur1 : 1 contract	130	12,7%
	Eurmore1 : more than 1 contract	58	5,7%
CONTRACTS : Number of research contracts (excepting European contracts)	Contract0 : 0 contract	509	49,9%
	Contract1: 1 contract	248	24,3%
	Contractmore1 : : more than 1 contract	263	25,8%
PATENT: Number of patents owned by the firm and invented by at least one researcher of ULP	Patent0 : 0 patent	937	91,9%
	Patent1 : 1patent	31	3,0%
	Patentmore1 : more than 1 patent	52	5,1%
PUBLI : Number of publications coauthored by a firm's member and at least one researcher of ULP	Publi0 : 0 publication	601	58,9%
	Publi1 : 1 publication	244	23,9%
	Publimore1: more than 1 publication	175	17,2%
DYADIC: Number of links concerning only ULP and the firm	Dya0 : 0 link	342	33,5%
	Dya1 :1 link	303	29,7%
	Dyamore1 : more than 1 link	375	36,8%
INDUSTRIAL: Number of links concerning at least one second private partner	Indus0 : 0 link	717	70,3%
	Indus1:1 link	207	20,3%
	Indusmore1 : more than 1 link	96	9,4%
UNIVERSITY: Number of links concerning at least one other academic partner, and no other industrial	Univ0 : 0 link	758	74,3%
	Univ1:1 link	181	17,7%
	Univmore1: more than 1 link	81	7,9%
Geographic location	Alsace	Alsace	116	11,4%
	France	Ile-de-France	221	21,7%
		Rhone-Alps	47	4,6%
		Other French regions	148	14,5%
	International	Germany	101	9,9%
		Other country of Europe	177	17,4%
		United-States	121	11,9%
		Other countries	89	8,7%
Sector of activity	Pharmacy	Pharmacy	323	31,7%
	Chemical industrial	Chemical industrial	197	19,3%
	Mechanical equipment	Mechanical equipment	87	8,5%
	Instrumentation/IT	Instrumentation and precision equipment	73	7,2%
		Electronics, computer	73	7,2%
	Traditional industry	Traditional industry	31	3,0%
		Metallurgy	30	2,9%
		Food industry	38	3,7%
	Networks and services	Services	47	4,6%
		Technical service and software	84	8,2%
		Network services (telecom, energy, transportation)	37	3,6%
Size and status	Indpt<50	Small independent firm (< 50 employees)	201	19,7%
	Indpt 50-500	Independent firm (50-500 employees)	123	12,1%
	Indpt 500-10000	Independent firm (500-10000 employees)	92	9,0%
	Indpt >10000	Large group (independent firm > 10 000 employees)	85	8,3%
	Ssg	Subsidiaries of small groups (group < 10 000 employees)	174	17,1%
	Slg	Subsidiaries of large groups (group > 10 000 employees)	345	33,8%

Table 3. **Correlation between the variable of link and the characteristics of the firms**

	Eur1	Eurmore1	Contract1	Contractmore1	Patent1	Patentmore1	Publi1	Publimore1
Pharmacy	**-0.12110**	-0.09430	-0.11560	0.02750	0.06360	0.07220	0.14690	0.18770
Chemical ind.	-0.04240	-0.09050	-0.15030	0.07200	-0.00360	0.05280	0.08200	0.10910
Mechanical equipment	0.08330	0.07660	0.04780	-0.05960	0.02770	0.00900	-0.07250	-0.12030
Instrumentation /IT	0.09560	0.12930	0.00330	-0.05530	-0.03970	-0.06930	-0.02580	-0.03750
Traditional ind.	-0.03590	-0.03760	0.11530	0.07170	-0.00020	-0.04590	-0.09850	-0.07010
Networks and services	0.02050	0.01650	0.09950	-0.05630	-0.04780	-0.01880	-0.03210	-0.06890
Alsace	-0.12760	-0.07460	0.09210	0.18420	0.04450	0.04330	-0.10680	-0.00740
France	-0.21410	-0.11670	0.15980	0.21110	0.02810	0.08980	-0.11250	-0.01600
international	0.34170	0.19130	-0.25190	-0.39530	-0.07260	-0.13310	0.21930	0.02340
Indpte <50	0.01970	-0.09650	0.17950	0.05780	-0.04510	-0.01300	-0.13610	-0.09370
Indpt 50-500	0.03900	-0.01290	0.04280	-0.06000	-0.01290	-0.03110	0.00410	-0.05670
Indpt 500-10000	-0.02800	0.05570	-0.06680	-0.06820	0.08380	-0.01070	0.07210	0.02010
Indpt > 10000	0.01240	0.03320	-0.09650	-0.04800	0.00860	0.05910	0.09700	0.05100
Ssg	-0.04950	-0.01450	-0.10570	0.09970	-0.03000	0.04160	0.02170	0.14740
Slg	0.00640	0.03500	0.04670	0.01870	-0.00440	-0.04590	-0.05880	-0.06810

4. Collaboration patterns between ULP and its private partners: A typology

4.1 Methodology

To study the collaboration profiles of the private partners of ULP, we have performed a Multiple Correspondence Analysis (MCA) on the collaboration variables defined above, followed by an ascendant hierarchical classification (AHC). This methodology is well adapted for qualitative data, since our aim is to explore the diversity of ULP relations whereas a structural model would tend to emphasize the main trends.

First of all, the MCA is designed to analyze the relations between more than two categorical variables that can be presented in multi-way contingency tables. It allows us to identify the relationships between the variables retained for the analysis. More precisely, the total variation of the data matrix (the inertia) is computed by the usual Chi^2-statistics which measures the distance separating the original distribution from the one assuring the independence of the variables. Three main criteria can be used to retain the more discriminating axes of the analysis: the percentage of the inertia explained; the marginal contribution of the axes to the inertia explained; and the general meaning of the axis which will constitute the new synthetic variables (Benzécri, 1992). Since the more the number of axes retained for the AHC the more variance intra-class of the resulting classes, researchers often only keep two or three axes.

In a second stage, the individuals' co-ordinates on the selected axes are the inputs for the AHC, which is used to partition the population into homogeneous groups. The AHC algorithm proceeds as follows: at each step pairs are formed by merging the closest clusters in order to minimize the within-types variance and to maximize the between-types one. The comparison of these two values (intra vs. inter-class variances) is the criterion used for choosing the number of classes to be retained. Finally, in order to highlight the main characteristics of the individuals by class, the co-ordinates of the classes' centers are represented on the axes determined in the MCA.

The variables used for the typology are the following: the types of collaborative link ("number" of non EU contracts, of EU contracts, of co-publications and of co-invented patents), and the exclusiveness of the relationships between ULP and its partners ("number" of dyads, number of links involving another firm, number of links invoving another university and no other firm) . The specific attributes of the partners (sector, size, status and location) are used in the third and last stage of our study (cf. section 5.). It will consist in a multinomial logit regression. The aim will be then to capture some micro-foundations of our typology.

4.2 Results

Following the MCA, two axes are retained that explain 36% of the total inertia of the data, which is a good ratio (the first axis explains 19.5% and the second, 16.5% of this inertia)[12]. The co-ordinates of the individuals (private partners of ULP) of the sample on these axes enabled us to carry out an AHC which results in a partition of the population into four homogeneous classes, with an intra-class variance of 19.4% and an inter-class variance of 80.6%. This indicates a very good homogeneity of the firms inside each class. Thus these classes gather firms with similar profiles as regards the variables retained for the analysis[13]. The projection of the centers of these classes on the two factorial axes shows that the first axis strongly opposes Class 2 to Classes 1 and 4, whereas the second axis opposes Class 1 to Classes 4 and even more 3.

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[12] For instance, Carayol and Matt retained four axes that explain 39% of the total inertia of the data

[13] We have decided to form four classes of firms, because in the case of 3 classes the intra-class variance was equal to 31.8 and the inter-class variance was equal to 68.2. And in the case of five class, the variance intra-class was equal to 11.9 and the variable inter-class of 88.1, but in this case, we only separate the smallest class of 105 firms in two groups of 32 and 73 firms.

As Figure 1 shows, the *first axis* can be interpreted as opposing private partners with dyadic collaborative behaviors to those which on the contrary collaborate with several other organizations (industrial or universities) more particularly in the form of European contracts. The *second axis* is related to the frequency and variety of interactions with ULP. Two main types of private partners can be distinguished: those which collaborate only punctually (just one collaboration) to those which collaborate more regularly with the ULP. In this latter case, collaborations often include repeated co-inventions of patents or co-publications.

The results point the diversity of the collaborations strategies of ULP partners. We describe successively the four classes obtained according to their position on the two first axes of the MCA[14]. We also present for each class, their general characteristics (localization, sector of activity and size) summarized in Table 2. Nevertheless, we will not precisely detail these general characteristics since they will be reconsidered in the second stage of our study.

Figure 1. The projection of the classes' centers and the variables contributing to the first and second axes of the MCA.

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[14] All the indications which are to be given below and which relate to the form of the collaborations (bilateral vs. multilateral, patents, publications, contracts …) only concern firms relations with ULP.
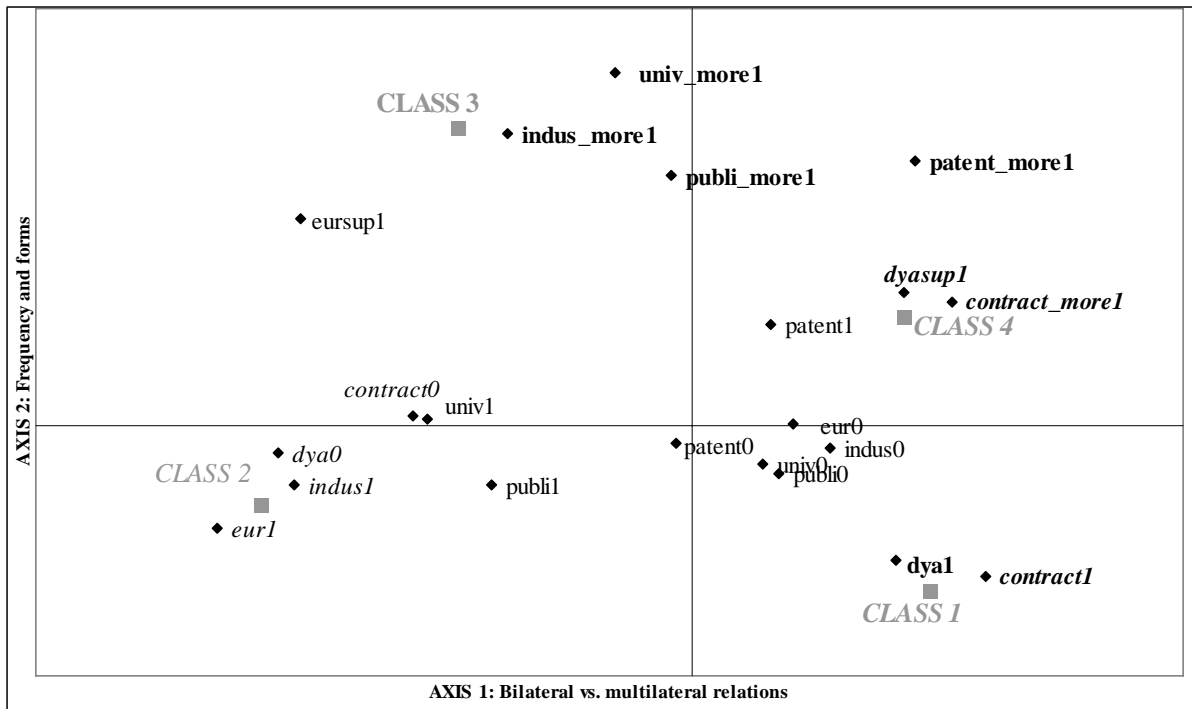
NB: The variables indicated in italic type contribute to the horizontal axis (factor 1) and the variables in bold contribute to the vertical one (Factor 2). The abbreviations used are presented in Table 1.

Figure 2. Number of firms by class
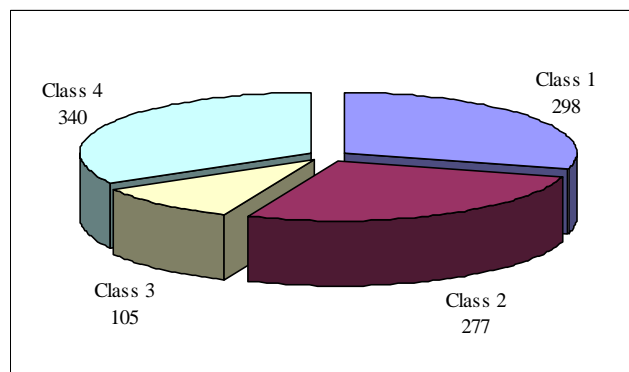
Source: Authors' calculation based on ULP partners database.

Class 1 gathers 29% of ULP partners which maintain **punctual and dyadic relations** with this university. In fact these companies collaborate punctually with ULP and mainly in the form of contracts. Thus, 78% of these firms collaborate through the achievement of one contract (not European) and in a bilateral way with a research unit of ULP (90% of these partners collaborate in a dyadic way with ULP). Few of them take part in publication activities (23% of the companies of this class have only one scientific publication and none

18

more than one, with ULP) and even less in patent activities (only 3% of them apply for only one patent and none of them for more than one). As we can see in Table 2, the private partners of Class 1 are not specialized in a given sector. Moreover, these firms are localized in Alsace, France and in the rest of the world in similar proportions as the global population of partners. Finally, they do not maintain long term relations with the ULP and it seems that they seek to punctually benefit from ULP's expertise in a specific domain.

Class 2 gathers 27% of ULP partners which maintain **punctual and multipartner relations** with this university**.** In fact, these companies collaborate also punctually with the ULP, but rather through European contracts (in partnership with several companies and/or several universities). About half of these companies take part in European contracts (45% of the class). Contrary to the firms of the first class, they do not achieve research contracts (this is the case for 99% of the firms of the Class 2). But in the same manner as the firms of the first class, the private partners which collaborate rather punctually with the ULP do not take part in patent activities (98% of them never applied for a patent in collaboration with the ULP). Nevertheless, they are often engaged in publications activities. As Table 4 below shows, Class 2 gathers actually two subclasses: the partners which take part in European contracts (42,3%) vs. those which collaborate with the ULP through one publication (53% of them).

Table 4. Publications and European contracts in Class2

	Publi0	Publi1	Publimore1	Total
Eur0	5	136	11	152
Eur1	112	5	1	118
Eurmore1	7	0	0	7
Total	124	141	12	277

In both cases, the collaboration is punctual but, in opposition to Class 1, these relations are multilateral since they are carried out with another private partner (60% of Class 2), or another university (45% of Class 2). They are more than average specialized in the sector of pharmacy, international companies, and rather subsidiaries of large groups.

Class 3 is the smallest class since it gathers only 10% of our sample of firms. It concerns firms which maintain **regular, multipartner and multiform relations** with ULP. These partners are characterized by both a strong intensity of collaboration (they have often more than one link with the ULP) and by a large variety of their relations with the university. In other words, they collaborate very regularly with ULP and in various forms: research contracts (16% achieved more than one contract), European contracts (45% took part in more than one

European contract) and in the form of multilateral relations. Moreover, their degree of openness is much higher than average : 70% have more than one link including at least another private partner. This result is highly compatible with a weak degree of exclusiveness (61% of Class 3 companies have no dyadic link, to be compared to the 33% of the whole population). It is worth noting also that these collaborations include, in the majority of the cases, some co-publications (62% of them) and/or patent co-inventions (16% applied for one or more patents). In 13 cases, the activities of publication and patenting are simultaneously achieved, indicating that both activites are not incompatible and might be complementary[15]. In terms of size and sector of activity, the firms of this class are more than average international companies distributed in various sectors of activity. Indeed, it should be noticed that there are very few firms originated from the Alsace region in this class (only five). By the means of a deeper inquiry, one can add that except for seven partners (including the five Alsatian firms), the firms of this class collaborate with several ULP research labs[16].

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[15] This result is highlighted by Carayol et Matt (2004) in the case of the more productive research labs of ULP.
[16] It can be mentioned that Alsatian firms have privileged relations with only one research lab or even with one or two academic researchers of ULP. In the same time, they have intense publications activities with them (more than one publication for each of them).

Table 5. Description of the classes

By class (in %)			CLS_1	CLS_2	CLS_3	CLS_4	Total
VARIABLES OF THE TYPOLOGY	European contracts	Eur0	98,7	54,9	50,5	97,9	81,6
		Eur1	1,3	42,6	3,8	1,2	12,7
		Eurmore1	0	2,5	45,7	0,9	5,7
	Contracts	Contract0	21,5	99,6	82,9	24,1	49,9
		Contract1	78,5	0	1,0	3,8	24,3
		Contractmore1	0	0,4	16,2	72,1	25,8
	Patents	Patent0	96,6	98,2	83,8	85,0	91,9
		Patent1	3,4	1,8	3,8	3,5	3
		Patentmore1	0	0	12,4	11,5	5,1
	Publications	Publi0	77,2	44,8	38,1	60,9	58,9
		Publi1	22,8	50,9	0	10,3	23,9
		Publimore1	0	4,3	61,9	28,8	17,2
	Dyadic	Dya0	2,0	97,8	61,9	0	33,5
		Dya1	90,3	1,4	3,8	7,6	29,7
		Dyamore1	7,7	0,7	34,3	92,4	36,8
	Industrial	Indus0	96,3	40,1	21,0	87,4	70,3
		Indus1	3,7	59,9	8,6	6,2	20,3
		Indusmore1	0	0	70,5	6,5	9,4
	University	Univ0	97,3	54,9	39,0	80,9	74,3
		Univ1	2,7	45,1	7,6	11,8	17,7
		Univmore1	0	0	53,3	7,4	7,9
VARIABLES OF THE MULTINOMIAL LOGIT	Sector of activity	Traditional ind.	14,1	4,0	5,7	11,8	9,7
		Pharmacy	21,5	35,0	36,2	36,5	31,7
		IT	14,1	16,6	21,0	10,6	14,3
		Networks and services	22,1	17,7	13,3	11,5	16,5
		Chemical ind.	17,1	18,4	16,2	22,9	19,3
		Mechanical equip.	11,1	8,3	7,6	6,8	8,5
	Location	France	50	19,1	23,8	55,0	40,6
		Alsace	14,1	1,4	6,7	18,5	11,4
		Internat.	35,9	79,4	69,5	26,5	48
	Size and Status	Indpte <50	27,5	18,4	7,6	17,6	19,7
		Subs. of large groups	26,2	30,3	33,3	43,5	33
		Subs. of small groups	19,5	14,4	20	16,2	17,1
		Indpte 50-500	14,8	14,8	9,5	8,2	12,1
		Indpte 500-10000	6,7	11,2	17,1	6,8	9
		Indpte >10000	5,4	10,8	12,4	7,6	8,3
	Total		**298**	**277**	**105**	**340**	**1020**
			29.2%	**27.1%**	**10.3%**	**33.3%**	**100%**

The last class (Class 4) gathers firms which maintain **regular and dyadic partnerships** with the university. Class 4, which represents 33% of ULP partners, is characterized by a strong intensity of the relations, the latter taking basically the form of research contracts (this is the case for 72% of the firms of this class). Those bilateral relations sometimes include co-patenting (15% apply for one or more patent) and co-publications (28% made more than one publication). Moreover, additional inquiry reveals that 53% of the firms that achieved more than one contract with the ULP collaborate with the same research lab within the ULP. Concerning the sector of activity, just like the companies of Class 2, the companies of Class 4 mainly belong to the pharmaceutical industry. They are also mainly French companies and more than average subsidiaries of a group.

Finally our results can be compared those obtained by Joly et al. (1996). We already mentionned that these authors, by analyzing the research contracts of approximately 20 labs of the INRA, identified three "logics" of collaborations between laboratories and firm. The "logic of proximity marked by interpersonal and durable relations between contractors shares some of the characteristics of relations with the partners of classe 4 in our typology (regular and dyadic collaboration pattern). The "logic of club" (achieved on the initiative of the authorities) seems to correspond to our Class 2 (where partners collaborate in a non exclusive way with the university). Lastly,we think that the "market driven logic" of Joly et alii has some common features with the collaborations undertaken by Class 1 ULP's partners (punctual and bilateral relationships).

5. Collaboration patterns and partners' specific attributes
The previous section highlighted that the companies which collaborate with the ULP have various profiles of interactions. They are opposed in their frequency of interactions with the university and around the exclusive character of their collaborations (bilateral vs. multilateral). To go further, we attempt to explain this diversity according to the specific attributes of firms : size and ownership status, industrial sector and geographical distance. Do they impact the frequency and the variety of the links between ULP and its private partners? For that purpose, we test membership to the different classes we obtained above using a multinomial logit estimation. The methodology is presented below.

5.1 The econometric model

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

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

with $\beta_j^* = \beta_j - \beta_0$, $\forall j = 1,2,...,m$. This formulation enables us to follow the constraint $\sum_{k=0}^{m} p_k = 1$ and the estimated parameters must be interpreted in relation to the reference group (i.e. to value *m=0*)[10].

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

$$\log(L) = \sum_{i=1}^{N} \sum_{k=1}^{m} y_{ik} x_i \beta_k - (m+1) \sum_{i=1}^{N} \log\left(1 + \sum_{k=1}^{m} \exp(x_i \beta_k)\right) \tag{2}$$

In our case, a firm belongs to one and only one of the four classes of the typology. Belonging to the Class 1 corresponds to the reference value of the endogenous variable. The selected explicative variables are the specific attributes of the firms. Our aim is to highlight the respective role of their geographical location, their sector of activity, their size or organization (independent vs. subsidiary of a group). The results of the multinomial logit estimation are presented in the Table 4 below.

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[10] For a precise description of the multinomial logit model, see Thomas (2000, pp. 91-94).

Table 6. The determinants of collaboration patterns of ULP partners

Group of comparison : **Class 1** (Punctual and bilateral relations)	**Class 2** (Punctual and multilateral relations)		**Class 3** (Regular and multiform relations)		**Class 4** (Regular and bilateral relations)	
Sector						
Chemical industry	Ref.		Ref.		Ref.	
Traditional industry	-0.789*	(0.417)	-0.451 ns	(0.536)	-0.497*	(0.298)
Mechanical equip.	-0.221 ns	(0.358)	-0.230 ns	(0.497)	-0.853**	(0.336)
Pharmacy	0.687**	(0.272)	0.884**	(0.361)	0.388 ns	(0.247)
Instrumentation	0.459 ns	(0.316)	0.855**	(0.404)	-0.465 ns	(0.303)
Networks and serv.	0.251 ns	(0.302)	0.175 ns	(0.428)	-0.844**	(0.290)
Location						
International	Ref.		Ref.		Ref.	
Alsace	-2.861***	(0.544)	-0.939***	(0.456)	0.993***	(0.268)
France	-1.721***	(0.207)	-1.292***	(0.277)	0.481**	(0.193)
Size and status						
Indpt<50	Ref.		Ref.		Ref.	
Subs. of large group	0.4719*	(0.266)	1.565***	(0.439)	0.939***	(0.238)
Subs. of small group	0.015 ns	(0.299)	1.293***	(0.461)	0.185 ns	(0.266)
Indpt 50-500	0.005 ns	(0.309)	0.559 ns	(0.523)	-0.104 ns	(0.307)
Indpt 500-10,000	0.366 ns	(0.366)	1.876***	(0.514)	0.568 ns	(0.368)
Indpt >10,000	0.734*	(0.383)	1.954***	(0.545)	1.174***	(0.375)
Constant	0.234 ns	(0.296)	-2.042***	(0.490)	-0.522*	(0.289)
Predicted probabilities[#]						
(Class1: 29.22% (0.132))	27.16%	(0.180)	10.29%	0.065	33.33%	(0.181)
Nb of observations			1020			
Log likelihood			-1171.8424			
LR Chi 2 (36)			336.35			
Pseudo R^2			0.1255			

5.2 Main results

The sector of the private partner

The sector of the private partner clearly appears to be linked to the collaboration patterns with ULP. In particular, belonging to the pharmacy sector significantly increases the probability to engage in multilateral collaborations with ULP (i.e. to belong to classes 2 or 3). This observation can be easily explained by the fact that the firms of this sector exhibit a science-based mode of production according to the taxonomy of Pavitt (1984). And despite the very significant role of the protection practices through intellectual property in this sector, the pharmaceutical companies often collaborate in order to produce advanced knowledge (Hamdouch and Depret, 2001; Malerba, 2002). Indeed, according to Bureth et al. (2005a and 2005b), these firms operate according to a "coopetition mode": there is a very strong competition between the various actors of the system, but the firms of this sector have

nevertheless to produce knowledge in collaboration with other organizations as well public as private. One can also notice that 60 % of the private partners that belong to the pharmacy sector have at least one publication in collaboration with ULP (27% of them have more than one publication). Indeed, they diffuse a share of the knowledge produced in collaboration with the university. The prevalence of this sector of activity can also be explained by the fact that this sector corresponds to the field of excellence of ULP. Indeed, in 2004, 35% of the ULP researchers are specialized in life science.

It also seems that the firms specialized in the sectors of instrumentation and information technologies, which are also innovative sectors, have a higher chance of being privileged partners of ULP (Class 3) as well as pharmaceutical firms.

The other sectors do not constitute discriminating factors with the exception of the service firms which have a weaker probability to maintain regular and bilateral partnerships with the university (Class 4). They maintain rather bilateral partnerships (Class 1) with the university, which are to a large extent consulting firms. In fact, they are KIBS which collaborate only once and in a bilateral way with the university, the latter bringing an expertise to them on a particular problem. Moreover, these KIBS can also play the role of a mediator between universities and firms (Muller and Zenker, 2001). In this case, these companies, even if they collaborate only punctually with ULP, can favor interactions between the university with other partners of these KIBS, and thus to lead to future collaborations.

The location of the private partner

The location of the private partners also appears linked to the collaborations patterns of these firms. Thus being located in France and even more in Alsace, increases the probability of undertaking bilateral partnership with the university labs (classes 4 and 1). Here, one can presume that these regional (or national) firms need a scientific expertise on a given problem. Moreover, our result highlight that the role of proximity is even more important in the case of intense bilateral relations with ULP (Class 4). This can probably be connected to the increased role of trust when exclusive, bilateral and confidential knowledge exchanges are at stake. The "logics of proximity" in Joly et alii (1996), which is close to our class 4 collaborative pattern, highlights the importance of trust and tacit knowledge.

An international firm has also a higher probability of being a regular partner of the university (Class 3) or to collaborate more punctually with the university in a multilateral way (Class 2). Indeed, the partners of these two classes collaborate in majority with ULP through European contracts which are obviously achieved with partners located in various European countries. We can also observe within these two classes, collaborations which combine with co-publications. In this case, ULP academic researchers co-publish with industrial researchers in their field of expertise. The collaboration will be achieved, even if the firm does not belong to the regional system of innovation, nor to the national system of the university.

Size and status of the private partner

Globally, the subsidiaries of large groups or large firms are rather regular partners of the university (Class 3 and 4). Our results also stress that the independent partners with a large size (independent of more than 10,000 employees) tend to collaborate more regularly with the university than small ones. These results are in line with the studies of Adams and al (2003) and of Mohnen and Hoareau (2002) who also show that large groups have a higher propensity to collaborate with universities than small independent companies.

6. Conclusion

Although limited to a single European university, our analysis provides interesting insight concerning the diversity of university-industry collaborative patterns. Exploring and analysing the data concerning the contracts, co-publications and co-invented patents of the University Louis Pasteur allowed us to elaborate a typology entailing four distinct collaborative patterms, each of them presenting a strong internal coherence. More precisely, we obtain the following collaborative profiles for ULP's private partners:
  - the partners who collaborate only punctually in an exclusive, bilateral way;
  - the partners who collaborate punctually in an open, multilateral way;
  - the partners who collaborate regularly in an open, multilateral way and through multiform relations;
  - the partners who collaborate regularly in an exclusive, bilateral way.
We complemented this first important outcome of our research (the typology) by an attempt to highlight the factors behind the four classes of ULP's collaborators, using a multinomial logit model. The results show that the size, sector and proximity attributes of the companies

contribute significantly to explain the membership to a particular classes. We can summarize the main outcomes of the model as follows:

- companies in hightech sectors (pharmaceuticals and information technologies/ instrumentation) and/or located in foreign countries have a higher propensity to activate open (multipartner) collaborations with ULP.

- domestic and regional companies have a higher propensity to activate exclusive (dyadic) and regular collaborations.

- large companies (and their subsidiaries) have a higher propensity to maintain regular, frequent collaborative relationships with ULP.

This study represents only a first step in a broader research project on university-industry relationships. To conclude we would like to mention a few limitations, which constitutes also future promising paths of investigation. First, the type of links we took into account was not complete : it would be worthwile to incorporate collaboration channels based on mobility of persons (students, scientists,…) as well. Second, organizing several interviews to collect information from the point of view of some ULP's partners would make it possible to examine whether the collaborative pattern of a given firm (for instance, activating open, multipartner and regular relationships) is specific to ULP or not. Does the firm collaborate with other universities or PROs? Does it activate the same collaborative strategy for any PRO ? Third, it would be interesting to apply the same kind of empirical analyse to other (large, scientific, and diversified) universities to evaluate the relevance of our four collaborative patterns in broader context. Finally, and most importantly, we intend to use a similar methodology to explore the diversity of collaborative links with additional information : the data concerning the research units of Univesity Louis Pasteur : personnel, performances, and so on.

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This list contains the Working Paper writen after January 2000, 1rst. The complet list is available upon request.

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