Measuring social proximity in the geography of innovation

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Measuring social proximity in the geography of innovation: application for the French science-industry collaborations study

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Abstract

Considering the role of interpersonal ties in the formation of innovation partnerships, the concept of social proximity has been increasingly used these recent years for the analysis of the geography of innovation. Nevertheless, the existing works reveal problems of measurement that prevent determining the precise weigh of social proximity in the partnerships build-up and deducing its effect on the geography of innovation. Our purpose is to fill in this gap by defining precisely social proximity as a modality of partners networking. On this basis, we propose an original method for empirically tracking the weigh and effects of social proximity, and we apply it to more than 200 cases of French science-industry collaborations. The combination of qualitative and quantitative approaches to construct and analyze relational data makes it possible to reaffirm both the significant and stable role of interpersonal ties and its significant but variable effect on the geography of partnerships.

JEL: O33, O31, O12

Key words: interpersonal ties, social proximity, science-industry partnerships, geography of innovation, mixed method analysis

1. Introduction

An abundant literature about the geography of innovation has been developed since the nineties as scholars observed the spatial concentration of innovation activities. The very first authors drew attention to the fact that firms locate close to universities in order to absorb knowledge considering that tacit knowledge was difficult to transmit from a distance. For some years now, while they recognized the relevance to study partners networking, authors have been criticizing this argument (see notably Breschi and Lissoni (2001)) and have considered the main challenge is the study of the dynamics of network formation (Autant-Bernard et *al*. (2007) ; Boschma and Frenken (2009) ; Ferru (2010)). In this context, they recognized the structuring role of interpersonal ties of the actors of innovation (ie. partners such as researchers or industrial project leaders) giving rise to the concept of social proximity. Beyond the various denominations, a relative consensus has emerged around the idea that social proximity matters in the partners networking process and therefore impacts the geography of collaborative innovation. Regarding its increasing use (based on the seminal typology of proximity developed by Boschma (2005) and the development of the social networks analysis), it has become an umbrella and ambiguous concept; in addition, the data used to assess social proximity suffer from the lack of relational data and thus appear objectionable in some cases (see Bernela and Levy (2015) notably). In this regard, to enrich the analysis of spatial dynamics of collaborative innovation through social proximity, the challenge is twofold: we need a clear and stabilized definition of social proximity and a robust methodology to construct data that gives a precise measure.

We propose to move in this direction through this paper by providing first a redefinition of social proximity based on the social embededdness thesis. We therefore reveal the

importance of interpersonal ties in the networking of innovative partners and distinguish it from other modalities of networking (sometimes integrated in social proximity). Based on this definition, we thereafter build up an original methodology to collect data about social proximity (through the qualitative "analysis of relational chain") and measure its effects (using the "quantified narrations method"). We applied this method to a set of 244 cases of collaboration between academic laboratories and companies in France. Our empirical work seeks to measure the role of social proximity of and to test "its spatial impact". In other words, it searches to answer the following questions: did partners use interpersonal ties to initially connect each other? How important is that modality of networking in comparison to others? Is this result independent from the partners' characteristics? Does the use of interpersonal ties impact the spatial dimension of partnerships? Are social and spatial proximities correlated?

We first give an overview of the studies underlying the role of social proximity in the geography of innovation (section 2). We then offer a redefinition of the concept and we show the need to develop a robust methodology to measure it (Section 3). We present the empirical work conducted on the basis of this methodology and the building of a relational database (Section 4), and we do a summary of the results from the quantitative treatment of the collected data (Section 5). The final part gives the conclusions from this work (Section 6).

2. Social proximity and the geography of innovation: insights and limits of the existing works

To open the black box of spatial externalities, authors increasingly pay attention to the structuration of innovation partnerships: they therefore highlight the importance of interpersonal relationships of star scientists (Hagedoorn and Schakenrad, 1994; Shan, Walker

and Kogut, 1994; Powell et al., 1996; Zucker et al., 1998) and reveal the innovative networks and their structures. Breschi and Catalini (2010) or Lissoni (2010) for instance focus on the important role of author-inventors in networking between researchers and innovators. For many researchers the spatial agglomerations of innovation activities (already demonstrated particularly by Acs and Audretsch, 1988; Jaffe, 1989; Audretsch and Feldman, 1994 and many others) can be explained by this social networks and the fact that for the most part these are local. More generally, existing works show that social relationships are formed more easily in the neighborhood: "the greater the distance, the less contact and support" (Mok et al.,2007, p.434). Some empirical studies (Wellman (1996) on a sample of residents of Toronto, Fischer (1982) on the population of San Francisco and Grossetti (2007) on Toulouse) confirm that personal networks include a large share of local relationships. This is also the case in studies directly inspired by the new economic sociology, like the already cited study by Powell and Brantley (1992), which explicitly refer to it, or like those of Saxenian (1994), or Ferrary and Granovetter (2009) on Silicon Valley.

Based on this scholars, authors increasingly used the concept of social proximity to highlight the role of interpersonal ties on the geography of innovation (Boschma, 2005; Maggioni et al., 2007; Agrawal et al., 2008; Massard and Mehier, 2009; Huber, 2012; Caniels et al., 2014; Hansen et al., 2014; Steinmo, 2015, etc.) and are studying the overlapping between social and spatial proximities in innovation partnerships. Besides other forms of proximity[1], social

[1] Following the seminal typology of proximity developped by Boschma (2005), besides social proximity four dimensions of proximity are considered :cognitive, organizational, institutional and geographical. By cognitive proximity, it is meant that people sharing the same knowledge base and expertise may learn from each other.Organizational proximity is defined as the extent to which relations are shared in an organizational arrangement, either within or between organization. Institutional proximity is associated with the institutional framework at the macro-level. Geographical proximity refers to the spatial or physical distance between economic actors, both in its absolute and relative meaning.

proximity could be defined in terms of socially embedded relations between agents at the micro-level based on friendship, kinship and past experience, etc. (Boschma, 2005). The concept is sometimes denoted as personal proximity[2] (Schamp et al. 2004) or as relational proximity (Coenen et al. 2004) to express the same idea. These authors have enhanced the empirical approach through social network analysis to measure the significance of this social proximity. Most of them use geolocation databases of individuals and their inter-relations, from which they can identify collaboration networks and formalize network analysis. Despite recent technical refinements, these works face a data problem. Either they are based on relational data derived from "output data" such as co-patent or co-publication[3] and the social proximity (ie. the existence of interpersonal ties) between partners are identified through their results; either, they are based on *consortium* data (european projects, clusters projects, etc.) and the partners networks are studied through the questionable hypothesis of complete graph representation (see Breschi and Cusmano, 2004; Autant-Bernard *et al.,* 2007; Roediger-Schluga and Barber, 2008; Balland, 2012; Vonortas, 2013, Grandclement, 2011; Levy and Talbot, 2014). According to this hypothesis every dyad of partners involved in a common innovation project interacts in a homogeneous way. Authors transform bipartite (or 2-mode) network projections – which link actors to the projects in which they are both involved – into unipartite (or 1-mode) projections linking together pairs of actors involved in the same project. The work of Bernela and Levy (2015) gives empirical evidence of the abuse of the hypothesis since 8,5 % of ties between project participants are characterized by the absence

[2] On the contrary, by using personal proximity, based on the homophily principle, some authors which to insist on property that is endogenous to the individual (see Werker et al., 2014 ; Broekel and Boschma, 2012; etc.).
[3] "A growing number of studies use patent information to apply social networks analysis (…). Some authors link inventors directly by *assuming* relations between inventors who jointly worked on patents" (Graf and Henning, 2009, p. 1353, underlined by the authors).

of real interaction. Alongside these works based on the hypothesis of complete graph representation, authors measure social proximity (and the existence of interpersonal ties) thanks to the observation of former participations in a common project. The interaction between partners is still assumed: partners can be integrated into a project without necessarily having met all the partners and / or without having really worked together (as it is common observed for large projects such as European one since they require a large number of participants from various domains). Empirical works searching to assess social proximity face therefore a data problem due to the lack of relevant data. Aware of these limits, some authors recently developed new methodology to perform the social proximity measurement (see notably Steinmo and Rassmussen, 2016).

3. Redefining and measuring social proximity

3.1 Social proximity as the embeddedness of actors in interpersonal ties

Regarding the acceptance of the social proximity concept in the literature, we also adopt by simplicity this denomination but it appears necessary to give precisions. We first consider the concept of to be rooted in the socio-economic literature and particularly in the embeddedness thesis developed by Granovetter in a famous article published in 1985. Granovetter defended the contention that economic activities depend on interpersonal relationships in which the actors are involved and called this dependence embeddedness. This proposition has several implications. On the one hand, economic activity is dependent on more general social structures that are not social groups or categories but networks (Wellman and Berkowitz, 1988). Second, the relevant level of economic action is not that of companies or organizations in general but that of the individual actors and their relationships. Thus, relying on a study by Eccles (1981), Granovetter shows that relations among companies (prime manufacturers and subcontractors in the construction field) are underlain by interpersonal relationships, thereby

sketching a “community.” The embeddedness theory as advanced by Granovetter was also the subject of a certain number of criticisms (for example, Portes (1998) or Baret et *al*. (2006)). In particular, the concept of embeddedness does not really explain the logic that makes it possible to share without going through interpersonal relations. In his study of the labor market, Granovetter distinguished different ways of getting a job: “personal contacts” (56% of cases), formal means (placement agencies, etc.) (19%), “direct approaches” (spontaneous applications) (19%) and miscellaneous other means (6%). Granovetter was especially interested in personal contacts, leaving out the 44% of cases that did not involve social relationships. This premise of the primacy of social networks can be seen as a form of relational reductionism, ignoring the reality of organizations (Grossetti, 2005).

To study the spatial dynamic of collaborative innovation, we consider here the role of social proximity as a modality of networking with partners and not as a result of innovation activities. In this perspective, social proximity is used to analyze the process of partnerships build-up and is therefore a mean to reintegrate the necessary dynamic perspective of the innovative collaboration; we also restrict social proximity to the embeddedness in interpersonal ties leading to distinguish it accurately from the other modalities of partners networking. When the actors involved in an interaction are not connected by interpersonal relationships, they indeed rely on other modalities of partners networking. These resources may include material systems (directories, Internet sites, newspapers, etc.) as well as organizations or people whose role is to put people in contact (transfer centers, promotion centers, innovation agencies) (notably). We consider these coordination resources to be anything that allows an exchange without going through social-relationship chains, all systems and institutions have made it possible to put public researchers and their industrial counterparts in touch with one another.

We therefore distinguish, beside interpersonal ties and social proximity, two subcategories of coordination resources mobilized in the formation of collaboration:

1) the market resources to which most firms and scientists have access (advertisements, conferences, reputation, media, professional-training markets and contracts) as already noticed by Carayol (2003), Mansfield (1991), Bozeman and Wittmer (2001) Levy et al. (2009), etc.
2) the specific organizational resources of the partners or institutions dedicated to putting laboratories and enterprises in touch with one another (innovation agencies, professional interface institutions, theme days, etc.) as already underlined by Ponomariov and Boardman (2010), Eom and Lee (2010) notably.

To coordinate with one another, the actors therefore have the opportunity between turning to social relations, calling on market resources, or making use of organizational resources see table 1). This distinction between interpersonal relations and coordination resources is in part similar to the classic opposition in neo-institutionalist economics between network and coordination by market or organization (Powell, 1990). Of course, actors may combine all three modalities, but most often we can identify the main form of networking by focusing on the first contact between partners, or by using appropriate methods of narration (cf. infra).

Table 1: Modality of partners networking

Networking procedure	**Subcategories**
Interpersonal ties / social proximity	Professional relations (research colleagues, business colleagues) Nonprofessional relations (family, childhood, associations, friendships) Relations associated with education (students, teachers)

Market resources	Contracts market (contracts with clients, subcontractors, contract-givers) Traineeship market[4] Research market (tenders) Reputation Seminars, conferences, trade shows, fairs (large-scale) Media (press, Internet, publications, *etc*.)
Organisational resources	Projects (competitiveness clusters) Public and semi-public structures (transfer centres) Closed meetings and invitation-only theme days Professional bodies (clubs, technology associations, expert commissions) Relations associated with the organisation of the firm or laboratory

3.2 Methodology to measure the weigh and spatial effect of social proximity

As stated previously, since relational data are unavailable or not accurate enough to assess the role of social proximity in the formation of collaborations, it is crucial to have a sufficiently sound method for obtaining them and revealing interpersonal ties and social proximity. In this perspective, our proposition is twofold: we propose to collect relational data directly from the people involved in the collaborations and to simultaneously give systematic results and test their correlation between social proximity (ie. interpersonal ties) and spatial proximity (ie. local collaborations). In this perspective, we use a mixed method that associates qualitative

[4]Some collaborations originate from a student traineeship, obtained in response to an offer put out by the firm to educational institutions.

approaches allowing to collect relevant and precise data and quantitative approaches permitting to realize statistical and econometric treatments. More precisely, the collect of data is based on the relational chains method in which it is not a matter of analyzing static structures but rather of recourse to interpersonal relations in order to access resources[5]. Only relations actually mobilized in concrete actions are taken into account. The method was used in the seminal work of Granovetter (1974), dealing with obtaining a job. However, it fell into oblivion face development approaches so-called comprehensive and personal networks. This method has been particularly developed in France during the last ten years. Since the initial work of Grossetti and Bes (2001) developed for the analysis of innovation, the method has been refined on the one hand (see Grossetti, 2011 notably) and expanded to others contexts and research topics (see for instance Grossetti and Barthe (2008), Berrou and Gondard-Delcroix (2011), Ferru (2010)).

Applied to the case of innovative collaborations, this method consists of reconstructing the build-up process of collaborations by focusing on the initial modalities of partners' networking. We did this based on in-depth interviews[6] with academic researchers and company heads. The analytical unit is therefore neither the laboratory nor the enterprise but the collaboration between them. A collaboration implies the existence of a contract between the parties, but it may encompass several successive contracts when they involve the same

[5] In guides to analysing social networks (Degenne and Forsé (1999) for example), it is customary to make a distinction between approaches by personal networks, in which relational neighbourhoods are studied around selected actors without making any hypothesis on the relations they might have among them (and without being concerned about these relations), and approaches by complete networks, in which one starts with the existence of resources common to certain actors, and hence likely links among them, in order to select the latter. Analyses of personal networks or complete networks are not suitable for understanding the role of interpersonal ties in the networking of partners.

[6] Questionnaires tend to underestimate the mobilization of personal relationships (Chauvac , 2011); Similarly, a self-administered questionnaire makes it more random entry relational channels , especially when they go beyond a single intermediary and appear difficult to implement given the variation and complexity stories and contexts.

partners. For each collaboration, we try to go back as far as possible by placing it in the career of the researchers or company heads. Hence the history of a collaboration starts well before it led to the signing of a contract. We are especially careful to hear about the genesis of the collaboration, the objective being to identify the modality that initiated the networking of the partners, or in other words to determine how the partners met at the time of their first collaboration. During interviews, we use specific questions that will yield precise information on social relations. When the interviewee cites a person's name, we ask whether this is someone he or she knew beforehand, in what context this person was met, and for how long the person has been known. After the interviews, the researcher prepares a detailed account of the collaboration and, when necessary to clarify information, he submits this account to the interviewees. (cf. box 1).

Box 1: A collaboration story

Story 022: Collaboration between an automotive manufacturer (located in Ile-de-France) and an engineering science laboratory (L47)

*The partnership (R1) between the two partners is not new (they had collaborated once before)**.** The partners renewed a former partnership for the new research project. The automotive manufacturer wanted to conduct thermo-aerodynamic research on automotive brakes. One of the firm's scientific directors went to a conference where a researcher explained his work about the item of interest to the firm. "The scientific director was impressed by the results," explained the researcher. Hence, the manufacturer went to the researcher to discuss and find out if his laboratory might be interested in working with them on this subject. Hence, the contact was made possible by a conference, which is considered a market resource.*

This account forms the basis for coding: we grouped together the situations we encountered and coded them according to the categories of networking procedures proposed earlier. In the first category – mobilization of interpersonal ties – contact results from the existence of a prior relational chain linking the people deciding on the collaboration. In the second category – use of operational coordination resources – contact is established under the aegis of an outside organization that causes, willingly or not, interactions among members of organizations who will subsequently be led to collaborate. Finally, in the third category – mobilization of market coordination resources – contact results from the initiative of one of the partners who relies on the available information resources (directories, databases, Internet sites) or their meeting at a collective event (conference, trade show), which can be defined as a market coordination resource. Above the modalities of partners networking, data related to the location, scientific specialization of partners and data about the spatial dimension of partnerships are also coded and integrated in the database in order to realize the statistical treatments: 1) cross tabulations and tests of independence to measure the weigh of interpersonal ties and spatial proximity and to check its independence from the partners characteristics; 2) econometric model (logit) to test the correlation between social proximity between partners and the geography of innovative partnerships. Non coded parts of interviews are used as a discourse analysis and will be mobilized for a better understanding of the formation process of partnerships and to interpret the quantitative results.

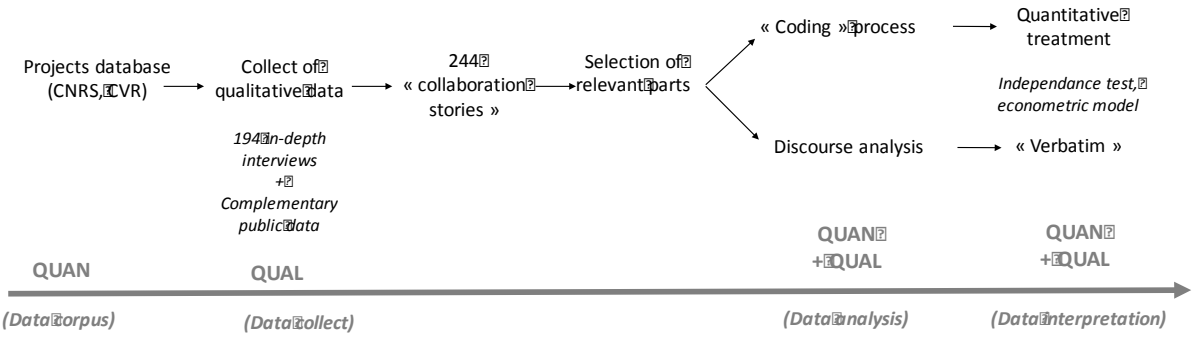
4. Operationalization of the method: data collected and treatments implemented

Building relational data relating to nearly 250 cases of partners networking allows us to measure and test the correlation between social proximity and the spatial dimension of collaborations through different statistical and econometric treatments.

4.1 Study corpus and sample

Applying the methodological framework presented earlier, we collected qualitative data about the initial networking of partners and analyzed them (through coding and discourse analysis) in order to realize quantitative treatments, interpreted thanks to verbatim. The following chart sums up the operationalization of the method in our case.

Figure 1 : Operationalisation of the method



Nota Bene : QUAN for « quantitative approach » and QUAL for « qualitative approach »

More precisely, the relational data were collected through two sets of interviews. Data collection relies on the same method presented earlier and in both cases involves formal collaboration contracts (either under way or completed) between a laboratory and a firm.

The first set of interviews, conducted between 1999 and 2001, involves only the laboratories of the engineering department at the Centre National de la Recherche Scientifique (CNRS), the France's leading government research agency. The second, conducted between 2007 and 2009, concerns the contracts made by the laboratories of the University of Poitiers, whether they belong to the CNRS or not. Construction of the overall sample therefore relies on two databases: one covers all the contracts signed by CNRS units with outside bodies between 1986 and 2005 (approximately 33,100 with companies), the other brings together all of the information collected by the Poitiers CVR (Research Development Unit) and relating to

contracts signed by Poitiers University academics from 2004 to 2007 (about 300 with companies).

With regard to the CVR database, we note that on the laboratory side the engineer and chemical sciences researchers are especially active in terms of industrial research, accounting for more than 70% of the contracts. On the manufacturer side, they are for the most part establishments belonging to the aeronautic and automotive construction sectors or specializing in R&D and engineering. Hence, we find as recurring partners such companies as Snecma, Airbus, Renault, PSA, and major research centers such as Anjou Recherche, Centre de R&D de Veolia. As these are contracts signed by CNRS units, we also note the extreme concentration of the contracts in favor of a few laboratories (50% of the contracts are signed by just 9% of the laboratories) and a few firms (50% of the contracts involve only 3% of companies). The most-represented scientific departments of the CNRS are the chemical sciences (29%), life sciences (20%) and engineering sciences (17%).

We built our sample based on these two databases; more specifically, we selected researchers who held scientific responsibility for contracts and asked them to tell us about several collaboration stories. Each story collected from a researcher was complemented with interviews of the manufacturer partners or other participants (another researcher, doctoral student funded as part of the collaboration, outside body that was involved, etc.). The investigators conducted 65 initial interviews with the researchers, which we complemented with 129 interviews, (83 with manufacturer partners, 46 with other researchers or participants). We were thus able to reconstruct 244 collaboration histories.

While our sample is representative of both of the mobilized databases, it is not representative of all science-industry collaborations in France. It is however sufficiently varied in composition

so that we can study the correlations between embeddedness in social networks and the characteristics of the laboratories and companies[7]. As we shall see that the share of collaborations initiated by chains of interpersonal relations is not very closely linked to the other characteristics tested, the corpus analyzed provides a good estimate of the magnitude of this proportion.

For our sample as a whole, an essential share of the manufacturers involved in the collaborations studied (61%) corresponds to large-scale industrial groups. On the partner laboratory side, they are specialized in engineering sciences (ES) or information technologies (IT) in 51% and 33% of the cases, respectively. The researchers involved in these collaborations are located in six research clusters. Of the collaborations studied, 130 involve a laboratory in Poitiers, 50 a laboratory in Toulouse, 28 a laboratory in Bordeaux, 21 a laboratory in Grenoble, 22 a laboratory in Montpellier, and 5 a laboratory in Clermont-Ferrand. Thus we can distinguish laboratories located in large centers (Bordeaux, Toulouse, Grenoble, Montpellier) from those located in medium-sized centers (Poitiers, Clermont Ferrand).

Furthermore, based on previous studies (Ferru, 2010; Bès et al., 2010), we know that science-industry collaborations are characterized by repetition of the contracts, that while there is some volatility in the contracts, which are often fleeting, the laboratories have a certain loyalty to their manufacturer partners, especially with large companies (EDF, ELF, RHONE POULENC, SNECMA, ARIBUS, etc.).

With regard to the geography of the collaborations studied, 22% are conducted “locally" (i.e., the research laboratory and the firm are located in the same region), nearly three-fourths of

[7] Concerning the sample size, the saturation of the categories is increasingly the reference for estimating the end of the data collection and the sample size (Pourtois and Desmet, 1997).

the collaborations are conducted with a French partner outside the region and located primarily in Ile-de-France, this region being involved in nearly 40% of all the collaborations studied and in more than one French collaboration out of two.

4.2 Statistical and econometric treatments of qualitative data

After collecting these qualitative data and ensuring their consistency for both corpuses, we have a set of original variables, presented in the following table.

Table 2 : Data used

Variable name	Variable meaning	Procedure name	Procedure meaning	[a]N=1	[b]N=0
$SCdomain_k$	Laboratory's scientific domain	IT	Information technology	80	164
		ES	Engineering sciences	126	118
		$others$	Biological sciences, chemical sciences, humanities and social sciences, physical sciences	38	206
$city\_size_k$	Size of the laboratory's city	$large_{center}$	Toulouse, Bordeaux, Grenoble	122	122
		$average_{center}$	Poitiers, Clermont-Ferrand	122	122
loc_k	Spatial dimension of collaborations	non_local	Non-local collaborations	185	59
		$local$	Local collaborations	59	185
$mod\_contact_k$	modality of the networking	$interpersonal_{tie}$	Social relations	101	143
		$market$	Market resource	57	187
		$orga_{res}$	Organisational resource	77	167
		$undetermined$	undetermined	9	235

[a]N=1 refers to the number of data having the value 1.

[b]N=0 refers to the number of data having the value 0.

In order to complete the qualitative analysis of the descriptive statistics, econometric treatments were done on 235 data (9 networks remaining undetermined as we see in Table 2).

After measuring the weight of social proximity (ie. the use of interpersonal ties) relating to recourse to other modality of partners networking, independence tests are done between the various networking procedures (interpersonal relations, market resources, organizational resources) and various characteristics of the partners (laboratory's scientific domain and size of the city) and of the partnership (geography of the collaboration). By testing these different relationships of dependence, we can verify whether the characteristics of the actors involved in the collaborations influence recourse to social proximity and whether this latter is significantly associated with local collaborations.

Finally, we create a logistic regression model so as to clarify the links of dependency that prove significant. This enables us to verify the effects of social proximity deriving from the use of interpersonal relations by testing whether this network modality has a real correlation with the local dimension of collaborations. More specifically, we will test a binary logit. In the model tested, the variable explained corresponds to the local dimension of the collaboration, noted as LOC_k, and the explanatory variables to the various potentially determining factors: the nature of the network modalities and several characteristics of the partners. More specifically, we write the latent variable as LOC_k^* and the associated binary variable as LOC_k which takes the value 1 if the $k^{ième}$ collaboration is established at the local level and the value 0 otherwise.

$$LOC_k = \begin{cases} 1 \; si \;\; LOC_k^* \geq 0 \\ 0 \; sinon \end{cases}$$

With $LOC_k^* = \alpha + Z_k\beta + \mu_k$

Z is the matrix of explanatory variables and β the vector of the associated parameters.

The associated probability is therefore written as:

$$\mathbf{P}(LOC_k = 1|Z_k) = \frac{\exp(\alpha + Z_k\beta)}{1 + \exp(\alpha + Z_k\beta)}$$

We test two versions of this model to measure the influence of network modalities on the local dimension of collaborations at a level more or less disaggregated from interpersonal ties.

5. Results

5.1 Weigh of social proximity: the crucial and stable role of interpersonal ties

The data collected reveal the importance of social proximity in the formation of science-industry collaborations since 43% of the partnerships having been made possible by an interpersonal tie. The interpersonal relations mobilized to establish collaborations may be of different kinds. The largest share (47% of cases) concerns strictly professional relations among former colleagues or people having worked together on projects. For example, in one of our cases, an engineer with an interprofessional body who became the director of a university laboratory was able to negotiate contracts for his team with his former colleagues, enabling his team to grow quickly. Another frequent (39%) situation is the use of interpersonal relations deriving from the educational system (professor – former doctoral candidate or former students from the same graduating class). The importance of relations associated with education, and especially with former doctoral students, is well known (Bozeman and Mangematin, 2004). Thus, in our interviews, one researcher states that "*They are a key means*[8]*",* while another adds that *"They facilitate contact with the manufacturer, because they are familiar with the laboratory's know-how*". In one of our histories, for example, an engineer starts work after his training in a company that has regular collaborations with one of the laboratories at his school. After a few years, he changes jobs. Asked by his new employer to

[8] Verbatim have been translated by the authors.

set up a central R&D department, he immediately calls on the director of his school's laboratory and negotiates funding with it for a doctoral student: *"I've known the laboratory director for thirty years […], it saves time […], it made it possible to get started more easily". One* researcher explains that one of his collaborations with a foreign firm would not have been possible without this relation associated with education: before this former doctoral student was recruited into the company, the laboratory was already interested in the firm's knowhow and wanted to collaborate with it; it had tried to contact it via the Internet to propose collaborative projects, but the firm had never followed up. Fleming and Frenken (2006), Todling et al. (2008) and Giuliani et al. (2008) have already noted the importance of the recruitment of former doctoral students into companies for the establishment of science-industry collaborations. Finally, there are family or friendship relations with no tie to professional activity, which account for just 14% of cases of social proximity. In one of our histories, a collaboration between a laboratory and a large firm was established at the initiative of a doctoral student whose father had worked at the firm in question. It was the doctoral student's father who facilitated his son's and the laboratory's contact with the head of the department that subsequently entered into the collaboration.

The role of social proximity in partners networking is not, however, exclusive: coordination resources, whether market or organizational, seem essential and complementary to the interpersonal ties while allowing the networking of the partners in 57% of the collaborations studied. Market coordination resources are important (24% of cases). Conferences are an example of this. In one collaboration story, a firm in the automotive sector wanted to conduct thermo-aerodynamic research on braking systems. One of the firm's scientific directors then went to a conference on this topic and there met various university researchers presenting their results. The scientific director was interested in the studies presented by one of the

researchers from a Poitiers university laboratory. The manufacturer then went to talk to the researcher to find out whether his laboratory might be interested in research work in cooperation with their firm. But many collaborations get established simply because one of the two partners has received information about the other through the media, specialized or otherwise.

Contact between the worlds of science and industry can also be established through a person that is specifically responsible for this kind of work (33% of collaborations were initiated by an organizational resource), like transfer centers or competitive clusters. In one case, the founder of a small firm submitted a problem on controlling the strength of materials to an academic who heads up a regional center promoting technology transfer. The academic put him in contact with a researcher he knew in the field of the physics of materials. The researcher led them to one of his colleagues, a specialist in non-destructive control, with whom the manufacturer established a collaboration. The role of these transfer centers, however, is less significant than might be expected. Scientific or industrial bodies are a more common organizational resource in partners networking. In one of the cases studied, an academic and an engineer working in an interprofessional group are members of the same topical commission in a governmental structure. As a sideline to the commission's activity, they decide to establish a collaboration between their respective teams. Another example involves an engineer with an electrical manufacturing company; put in charge of establishing relations with engineering schools and laboratories, he joined the Arc Électrique club of Électricité de France. At a club meeting, he met a researcher with whom he began a collaboration that encompassed three different subjects and continued for some twenty years.

By cross-tabulating the three network modalities with the various characteristics of the partners, we find that the weight of social proximity remains relatively stable: whatever the scientific field to which the researchers belong, the collaborations were initiated through interpersonal relations in 40 to 50% of the cases. Likewise, whether the researcher is located in a large or small urban center, the weight of social proximity remains the same. The independence tests allow more rigorous testing of the links between the modalities of networking and the various characteristics of the partners involved in the collaborations.

Table 3: Results of khi² tests

		Market resource	**Organisational resource**	**Interpersonal ties**	**Total**	**Results of khi²**
$city\_size_k$	Large center	28	43	51	*122*	**X^2=0.74**
	Average center	29	34	50	*113*	**p=0.69**
	Total	*57*	*77*	*101*	*235*	**Independence**
$SCdomain_k$	IT	23	16	36	*75*	**X^2=7.50**
	ES	28	48	49	*125*	**p=0.11**
	Other	6	13	16	*35*	**Independence**
	Total	*57*	*77*	*101*	*235*	

NB:X^2 corresponds to the sum of the differences between the theoretical values and the observed values, and p corresponds to the likelihood of an associated error.

These results show the especially stable nature of social proximity in the formation process of partnerships. The geographic or discipline-related characteristics of the partners have no significant impact on the way in which science-industry collaborations begin: the density of the location does not favor recourse to interpersonal ties, nor does belonging to a specific scientific field encourage the use of organizational resources. the researchers' scientific specialization has no impact on mobilization of a particular modality of partners networking.

In addition, the likelihood of recourse to interpersonal ties does not increase significantly with the density of the actors' city.

5.2 Correlation between social proximity and spatial dimension of partnerships

by cross-tabulating the variables associated with the nature of the networking with those having to do with the geography of the collaborations, we find that the interpersonal ties are more frequently used when the collaboration is local. Conversely, recourse to coordination resources leads in a great majority of cases to the establishment of a national partnership. The khi² tests confirm part of these results (cf. Table 4): the nature of the networking influences the geography of the collaborations. If we break down the networking by interpersonal relations even further, a simple statistical cross-tabulation seems to show that non-professional relations allow the establishment of collaborations at a more restricted spatial scale (cf. Table 5).

Table 4: Tests of independence: networking modality and spatial dimension of collaborations

		Organisational resource	Market resource	interpersonal ties	*Total*	**Results of khi²**
loc_k	Local	16	9	32	*57*	**X^2=5.76**
	Non-local	61	48	69	*178*	**p=0.06**
	Total	*77*	*57*	*101*	*235*	**Dependence**

NB:X^2 corresponds to the sum of the differences between the theoretical values and the observed values, and p corresponds to the likelihood of an associated error.

Table 5: Type of interpersonal ties and local vs non-local collaborations.

Interpersonal ties	local	Non-local
Education-linked relation	12	27
Non-professional relation	11	3
Professional relation	9	38

Total	32	69

By definition, the khi² tests do not indicate the direction of the relationship of dependence between these two variables. We know however that interpersonal ties and coordination resources, whether market or organizational, exist before collaborations: they made possible the partners' networking and the formation of the collaboration. This leads us to think that the nature of the networking influences the geography of the partnerships, and to clarify this relationship using a logit-type econometric model in which the explained variable corresponds to the local (vs. non-local) dimension of the collaborations and to the initial network modality. The partners' discipline-related and geographic characteristics are integrated into the model as control variables.

The tested model provides several complementary results (sum up in the following table). The first version of the logit reaffirms the positive influence of social proximity on the local dimension of collaborations: the use of interpersonal relations multiplies the likelihood of establishing a partnership in the region by a factor of 2.5. Organizational resources seem to have no significant influence on the geography of collaborations. The second version of the model, with a finer breakdown of network modalities, makes it possible to further clarify the link between spatial proximity and social proximity. Whereas non-professional relations positively and significantly influence intra-regional partnerships – by multiplying the likelihood of establishing collaborations at this spatial scale by a factor of 14 – professional relations do not significantly influence the geography of collaborations. By cross-tabulating the variable associated with the size of the laboratory's location, we note that interprofessional relations are even negatively correlated to the local dimension, which can be explained by the small size of the local labor market for the small cities studied (cf. Poitiers). Relations associated with education (reference variable in our model) generate local collaborations, whether in

large centers or medium-sized centers, but to a lesser extent than non-professional relations.

Table 6: Result of the binary logit model

			Explained variable: loc_k	
			1st version	**2nd version**
		C	-1.84***	-1.46***
			(-3.57)	(-3.47)
Tested variables	$mod\_contact_k$	**Market resource**	Ref	-
		Organisational resource	0.18	-
			(0.37)	
		Interpersonal ties	0.91**	-
			(2.10)	
		Education-linked relation	-	Ref
		Non-professional relation	-	2.64***
				(3.78)
		Professional relation	-	-0.14
				(-0.32)
Control variables	$city\_size_k$	**Average urban centre**	-0.77**	-0.77*
			(-1.87)	(-1,79)
		Large Urban Centre	Ref	Ref
	$SCdomain_k$	**ES**	0.72*	0.64
			(1.67)	(1.50)
		IT	Ref	Ref
		Other	0,87	0.73
			(1.55)	(1.23)
				Wald Chi² test:
				non prof rel.=prof rel
				12.91***[a]
	N		*235*	*101*
	Log-likelihood		*-121.67*	*-115.40*

*Notes:*P<0,1, **P<0,05, ***P<0,00 .t-statistics in brackets*

[a] Chi² statistic for the hypothesis that the difference of the marginal effects of non professional relation and professional relations is zero

As these are geographic and scientific characteristics integrated into the model as control variables, we find that location in an average-sized urban center (Poitiers or Clermont-Ferrand) is a significant disadvantage in terms of local collaborations, as their density does not make it possible to find a potential partner locally. However, this control variable has a far more limited effect than network modalities, its odd ratio being around 2. This being the laboratories' scientific field, it plays only a very negligible role: the ES variable, significant at the 10% threshold in the first version of the model, is not significant in the second.

The results of this model complement and qualify the literature relating to the geography of social relationships. We show that it is not possible to systematically associate interpersonal ties with the local dimension of partnerships. Our work underscores the need to break down interpersonal ties according to their precise nature; non professional ties seem to favor the establishment of partnerships that are more geographically circumscribed than relations associated with education or professional activity. By intuition, this result may differ according to the territorial economic context (size, institutions, specialization, etc.) in particular job market; this result calls for additional cases to test this hypothesis.

6. Conclusion and discussion

Whereas the role of social proximity in the geography of innovative partnerships appears obvious in many empirical studies, there are very few studies assessing precisely its importance in relation to other modality of partners networking. Our article provides the first data to fill in this gap, proposing a redefinition of the concept – distinguishing social proximity (ie. the use of interpersonal ties) from other coordination resources more classic in economics, like market and organizations – and a sound method for empirically tracking

interpersonal relations. Application of this method allows the construction of relational data and contributes a new measurement of the role of social proximity in science-industry collaborations. We also checked various determinants of this social proximity and verified its correlation with the spatial proximity of partnerships.

A qualitative and quantitative analysis of these data reveals the greater weight of social proximity (interpersonal ties making possible the establishment of 43% of collaborations) and the complementary role of market and organizational resources. The role of social proximity varies little as a function of the discipline-related and geographic characteristics of the partners. Finally, our work confirms the existence of a link between social proximity and spatial proximity, while clarifying it: only non-professional relations significantly favor local collaborations.

Although the literature on science-industry collaborations focuses primarily on performance indicators, our work shows the need to explore the means and methods of analyzing the dynamics of these partnerships by considering the different time frames (genesis, negotiation, start of research theses or projects, exchange of data and results, end and continuation) and their differentiated issues.

Our results should of course be refined using larger and more varied corpuses, in terms both of disciplines and national contexts.

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