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Exchanging Information Through Social Links: The Role Of Friendship, Trust And Reciprocity

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Abstract: This paper shows that the features that characterize the exchange of information among individuals vary depending on the type of information exchanged (novel or specific) and the institutional affiliation of the individuals involved. It unbundles the concept of strong and weak links into three main tie characteristics: trust, friendship and reciprocity. Using data from a survey of nanotechnology researchers, we identify the characteristics of 594 links between researchers and individuals from different institutional groups (firms, governmental organizations and universities). Findings suggest behavioral regularities that are contingent on the kind of information being exchanged and the contact's institutional membership. For, instance, when university researchers exchange novel information between themselves, the level of trust becomes essential, but exchanges with individuals from other institutional settings (firms and governmental organizations) will be characterized instead by reciprocity and friendship. We discuss the implications of these findings for research on the relational perspective of social networks and university-society relationships.

1 Introduction

It is widely accepted that value creation activities draw on resources like information and knowledge, among others. Scholars have underlined the critical importance of investing in social relationships for acquiring such resources (Powell, 1990; Hansen, 1999; Lin, 2001). In fact, the establishment of social linkages between different types of actors has been considered as one of the most important channels through which information and other resources flow across different institutional spheres (Etzkowitz & Leydesdorff, 2000; Molas-Gallart *et al.*, 2000).

The analysis of social links has a great tradition in sociology going back to the classic work of Granovetter (1973). Granovetter argues that the strength of the links can explain how access to information takes place; particularly, he suggests that novel information flows through weak ties. Granovetter defines tie strength in terms of four main characteristics of the link: amount of time, emotional intimacy (or friendship), mutual confiding (or trust) and reciprocity.

Nevertheless, the literature highlights some additional difficulties that exchange partners face when transferring knowledge and information through social relations: actors may have divergent objectives and interests (Bouty, 2000; Wicks & Berman, 2004), and trading imbalances between partners may emerge during the process of exchange (Bradach & Eccles, 1989). Scholars have emphasized that these difficulties are significantly greater among actors from different institutional contexts; for instance, when they belong to different types of organizations (Powell, 1990; Bouty, 2000). As some researchers have pointed out, when two individuals interact instrumentally, they represent an interpersonal tie but also the group (Brass *et al.*, 2004) and institutional spheres (Leydesdorff, 2000) of which they are members. In other words, the characteristics of the individual tie cannot explain by themselves the way information is accessed by actors: there is a need to consider the role of context, and in particular of institutional affiliation. The sources and effects of friendship, trust and reciprocity can differ across institutional contexts (Keefer & Knack, 2005; Zaheer & Zaheer, 2006). For instance, the role of friendship in providing access to novel information may be different if the friend comes from a firm or from a government agency.

This interrelation between the characteristics of the tie and the institutional context framing the tie has not been addressed in the literature, and it is the object of this paper.

We will argue that the characteristics of a tie (friendship, trust, reciprocity) predict different exchange behaviors depending on the institutional affiliations of the partners. In short, this study stresses that institutional affiliation determines which tie characteristics are in the best interest for the exchange of information to take place.

The manner in which relational and institutional traits interact in exchange relationships has proved difficult to address. The traditional approach has focused on the relationship between the strength of the link (strong vs. weak ties) and the type of information (specific vs. novel) that flows through partners (E.g.: Granovetter, 1973; Burt, 1992; Hansen, 1999; Levin & Cross, 2004). Additionally, the extant literature applies a narrow operationalization of the concept of tie strength: studies measure tie strength by taking into consideration one, some, but never all the four tie characteristics identified by Granovetter. Consequently, the results could be biased, given that the concept of tie strength is multidimensional (Marsden & Campbell, 1984). To provide a more complete vision on information exchange processes within collaborative relationships, we include in our study all the four tie characteristics. We use these to characterize the one-to-one exchanges (dyadic relations), and analyze how institutional affiliation is related to the way in which individuals conduct information exchanges for two different types of information (specific and novel).

We first define and operationalize the main concepts used in the study and review briefly the literature about information transfer and social links, with a special focus on the importance of institutional affiliations. Then, we formulate hypotheses about how friendship, trust and reciprocity are related to the access to specific and novel information when exchange partners belong or not to the same institutional spheres. Afterwards, we present the empirical study; data, methodology and statistical techniques, followed by the analysis and comments on the results. Finally, we turn to the discussion and implications of this work on the relational perspective of social networks and university-society relationships literatures.

2 Information access and tie strength

Previous studies have shown that people habitually turn to others to acquire information (Granovetter, 1973; Burt, 1992), making social interaction an important aspect of knowledge transfer processes. The type of information and knowledge commonly

transmitted through social ties is basically of two types: specific and novel (Rowley *et al.*, 2000; Gnyawali & Madhavan, 2001).

Information is specific when interaction between individuals leads them to the acquisition of detailed information about the partner's activities, capacities, intentions and objectives (Uzzi, 1997; Rowley *et al.*, 2000). Specific information is therefore fine-grained and adapted to the partner's needs and provides more in-depth knowledge about a particular area of interest for the actors, helping them to complete and evaluate their own knowledge. Specific information is frequently tacit because it can only be combined and transferred between actors with a certain level of shared knowledge and experiences (Polanyi, 1966; Uzzi, 1997; McFadyen & Cannella Jr, 2004). In contrast, novel information refers to information about general events within the environment, such as emerging technologies, innovations or other significant changes. This type of information tends to be extensive and new. Moreover, it covers a greater variety of topics, which may or may not be of particular interest to the objectives of the actors. Its general nature makes its codification and transfer easier, even without a basis of interpersonal interaction (Rowley *et al.*, 2000; McFadyen & Cannella Jr, 2004). A large body of literature argues that the type of information actors tend to exchange depends on the type of connection developed between them.

Analysts have traditionally grouped connections into two categories: strong and weak ties¹. Many researchers agree that specific information is better transferred via strong ties and novel information via weak ones (Granovetter, 1973; Uzzi, 1997; Hansen, 1999; Rowley *et al.*, 2000). Strong ties are based on trust, friendship, reciprocity and frequency of interaction (Krackhardt, 1992; Uzzi, 1997; Brass *et al.*, 1998; Reagans & Zuckerman, 2001). Trust facilitates cooperation among social actors (Brass *et al.*, 1998), as well as transactions of resources and information (Krackhardt, 1992). Interaction frequency provides the necessary experience to allow participants to predict (a) which specific information the other needs, and (b) how the shared information would be utilized by the partner (Krackhardt, 1992; Uzzi, 1997). As a result, these strong links provide in-depth and specific knowledge in a particular area of interest for the individuals involved (Rowley *et al.*, 2000), thereby contributing to knowledge creation and dissemination capabilities. Therefore, when a strong tie exists, individuals acquire detailed knowledge

¹ This typology has its origin in Granovetter's (1973: 1361) seminal work.

about the other's capabilities, attitudes, behaviors and objectives, and hence detailed and customized information is exchanged.

In contrast, weak ties are defined as casual acquaintances between social actors (Brass et al., 1998), characterized by an infrequency of interaction (Granovetter, 1973) and based on neither friendship, trust nor reciprocity. However, these links can act as "local bridges" to other social circles beyond the individual's immediate environment, providing new information about opportunities and/or the availability of other resources (Granovetter, 1973; McEvily & Zaheer, 1999). In other words, weak ties are more significant to the discovery of new sources of resources because they are more likely to connect actors from different social circles (Granovetter, 1973).

3 Information access, tie characteristics and institutional affiliation

The impact of social ties on the reception of knowledge and information might however be contingent on the type of contact (Silverman & Baum, 2002). Tie characteristics (friendship, trust and reciprocity) may vary in level, degree and nature across institutional borders (Keefer & Knack, 2005; Zaheer & Zaheer, 2006; Olk & Gibbons, 2010), because of the idiosyncratic differences in value systems, cultures and norms inherent to each particular institutional sphere. In fact, Zaheer and Zaheer (2006) believe that exchange behavior depends on shared expectations, which are influenced by the different institutional spheres in which actors are embedded. Therefore, different institutional conditions can lead individuals to different exchange expectations. If expectations shape behavior, then it is likely that a particular actor will base their exchanges on one or more of the aforementioned relational characteristics, depending on their partners' institutional membership. This would hold especially true in the case of professionals that operate in multiple institutional environments. These professionals often maintain diverse logics of exchange with their partners (Dunn & Jones, 2011). Nevertheless, there are few studies that explicitly take into account exchange behaviors among partners from different institutional contexts and systematically analyze which relational features play a significant role in the transfer of both types of information.

The following sections develop hypothetical relations between a) varying degrees of tie characteristics (friendship, trust and reciprocity), b) access to both types of information and c) partners' institutional membership.

3.1 Friendship and access to information

Friendship entails emotional involvement with another person, and thus an interpersonal attachment and identification (Parsons, 1915; Blau, 1964). The parties' mutual affection and explicit interest in maintaining the relationship provide them with sufficient incentives to offer benefits to each other (Blau, 1964). Therefore, friendship implies commitment, in the sense that individuals tend to make periodic contributions to the relationship without expecting a reciprocal benefit for each particular contribution. An important consequence of friendship is precisely this sense of duty arising among individuals and the intrinsic motivation for being helpful (Blau, 1964; Granovetter, 1983). That is to say, friends do not shirk the social obligations between them (Parsons, 1915). In addition, friendship is greatly influenced by emotional and moral factors (Adams, 1967; Lydon *et al.*, 1997; Olk & Gibbons, 2010).

According to social exchange theory, friendship begins with an attraction to others who are socially similar and results from homophilious relationships evoked by expressive actions (Homans, 1950; Blau, 1964; Lin, 2001). Within this traditional approach, friendship ties identify clusters of people living in similar circumstances and possessing similar resources (or information) (Granovetter, 1973). Friends from the same institutional sphere will share the same value system, mores, and culture, as well as the same or very similar information resources (Törnblom & Fredholm, 1984). Therefore, it is unlikely that friends from the same institutional sphere will exchange novel information.

Nevertheless, friendship can occur among people from different social circles or institutional spheres (Villanueva-Felez, 2011). In this case, actors come into contact with information generated from within different institutional circles. The periodic contributions made by these friends to the relationship could be in the form of information about opportunities in their respective institutional sphere, which will be novel for both concerned. On this basis, we posit the following hypothesis:

Hypothesis 1: Friendship is positively related to the access to *novel information* when partners do not belong to the same institutional sphere.

While friendship may be positively related with the access to novel information, its effect on specific information is subject to conflicting influences. Friends are bound by “norms of loyalty” and may engage in unequal exchange that can therefore be considered inefficient (Clark, 1981; Törnblom & Fredholm, 1984; Bicchieri & Muldoon, 2011). Such inefficiencies emerge when the needs of the actors differ; then, the benefits given and received will not be comparable (Clark, 1981; Törnblom & Fredholm, 1984), resulting in an asymmetric relationship. Yet, the transfer of specific information requires efficient coordination between the parties (Hansen, 1999; Rowley et al., 2000), which stand in contrast to the inefficiencies related to friendship. Therefore, although friendship may support the exchange of specific information, it can also introduce inefficiencies in this exchange and thus work against it. For these reasons, friendship sometimes enhances the transfer of specific information, but in other occasions it may impede the attainment of this objective. Accordingly, we can hypothesize that the two effects cancel each other.

Hypothesis 2: Regardless of the partners’ institutional affiliation, friendship does not significantly affect the access to *specific information*.

3.2 Trust and access to information

Rousseau *et al.* (1998: 395) define trust as “a psychological state comprising the intention to accept vulnerability based upon positive expectation of the intentions or behavior of another”. It is based on both the perceived likelihood that implicit or explicit agreements will not be infringed upon (Madhok, 1995), and the belief that an exchange partner does not or will not act exclusively in a self-interested manner (Uzzi, 1997). Additionally, it is agreed that the development of trust increases flexibility and tolerance among partners. Trust is especially important in situations where ambiguity is present and the actors are contributing their own resources to achieve mutual benefits (Madhok, 1995).

Trust is likewise related to behavioral patterns. Aulakh *et al.* (1996) demonstrate that the fact that two partners trust each other is positively related to the establishment of governance mechanisms in the relationship. Under the umbrella of trust, actors often forgo including explicit details in their contractual agreements, even if this behavior

increases their exposure to risk (Macaulay, 1963). Consequently, reliance on trust becomes a significant *modus operandi* in exchanges implying risk and vulnerability for those involved (Coleman, 1990), and where uncertainty is present because performance is difficult to measure (Madhok, 1995).

Nevertheless, building trust is not without cost (Madhok, 1995; Zaheer & Zaheer, 2006). Creation of trust involves a significant investment of resources for both participants in the relationship, e.g. their time, their monetary assets, etc. (Madhok, 1995). In fact, Wicks and Berman (2004) hold that such a costly governance mechanism should be employed only when it is essential: in situations with considerable degrees of uncertainty, vulnerability and interdependency (Madhok, 1995; Zaheer & Zaheer, 2006).

Levin and Cross (2004) point out that, depending on the type of knowledge being accessed trust performs a major or minor role in the exchange. When accessing novel information, trust may not be critical: information can be codified and therefore remains independent of the source's competency (Levin & Cross, 2004). In this situation, partners do not need to invest in trust to ensure their access to novel information. In fact, the literature suggests that investments in trust are an inefficient way to acquire novel information (Granovetter, 1973; Hansen, 1999; Rowley et al., 2000; Levin & Cross, 2004).

Nevertheless, we believe that the aforementioned state concerning the transfer of novel information is only valid when the contacts are not direct competitors. Ties with potential competitors are more difficult to manage because of the greater opportunities to behave opportunistically (Silverman & Baum, 2002). These difficulties increase when agents operate within technologically dynamic contexts. In such environments, the agents' performance is positively related to early access to new information (Powell, 1990; Rowley *et al.*, 2000). In cases of co-opetition, the exchange of novel information could lead to situations where actors are exposed to risk and vulnerability. In these circumstances, trust helps partners in an exchange to predict what each other will do and can do with the newly supplied information, facilitating the transfer of information.

It is unlikely that partners from different institutional spheres will be direct competitors as they usually operate in different contexts and may even have different kinds objectives (Powell, 1990). Therefore, when the contact comes from another institutional context, trust may not be a requirement to access novel information (no risk is present). On the

contrary, potential competitors conventionally come from the same institutional sphere. In this case, trust is likely a prerequisite for the transfer of novel information to take place. On the basis of the above, we propose the following hypotheses:

Hypothesis 3a: Trust does not significantly affect *novel information* access when partners do not belong to the same institutional sphere.

Hypothesis 3b: Trust is positively related to *novel information* access when partners belong to the same institutional sphere.

Within a relationship based on trust, partners manifest a mutually positive orientation towards one another (Madhok, 1995; Rousseau *et al.*, 1998). This orientation, within relationships based on trust, help the actors attain a significant level of efficient coordination. The literature is replete with studies that demonstrate the positive impact of trust on cooperation, support and joint problem-solving between actors (Uzzi, 1997; Levin & Cross, 2004; McEvily & Marcus, 2005). Therefore, trust offers the conditions that permit and enhance the exchange of specific information between actors. Levin and Cross (2004) demonstrate that the greater the level of trust the easier it is to transfer specific information that positively influences a knowledge seeker's work. In this situation, actors must trust the competence of their sources, because the access to specific information directly affects actors' work performance.

The degree of risk, uncertainty and vulnerability incurred when exchanging specific information could certainly vary, depending on the partner's institutional affiliation. It is possible that risk and vulnerability is greater in links with actors from the same institutional sphere (greater likelihood of being competitors), while partners from different institutional spheres experience greater levels of uncertainty. In any case, and regardless of the actors' institutional affiliation, the exchange of specific information is linked to situations of either risk or vulnerability or uncertainty. Therefore, we posit the following:

Hypothesis 4: Regardless of the partners' institutional affiliation, trust is always positively related to the access to *specific information*.

3.3 Reciprocity and access to information

Reciprocity² is understood as the coequal investment and result perceived by each member in a social relationship, related to the individual's internal standards (Pritchard, 1969). It can likewise be defined as an exchange pattern of mutual benefits between two actors (Gouldner, 1960). Reciprocity, unlike friendship, does not necessarily rest on mutual identity because individuals are not compelled to be emotionally invested in the relationship. Nevertheless, reciprocity induces a feeling of indebtedness among and towards exchange partners (Westphal & Clement, 2008). Consequently, reciprocity imposes obligations on the actors: actors must accept and repay favors offered even those unsolicited (Gouldner, 1960; Westphal & Clement, 2008).

Uhl & Maslyn (2003) believe that reciprocal behavior can be understood by decomposing it into its three constituent elements: equivalence, immediacy and interest. Equivalence refers to the equal *amount* of goods and services given and received within the relationship. Other authors specify instead that equivalence requires the *value* of what is exchanged to be roughly equivalent (Gouldner, 1960; Westphal & Clement, 2008). Immediacy refers to the period of time between the action of receiving a good or service and its repayment. Interest refers to the actors' motives behind the exchange. Classical exchange theorists suggest that the primary motive for acting reciprocally is individual self-interest (Homans, 1950; Blau, 1964), with the specific goal of increasing the likelihood of receiving future favors (Westphal & Clement, 2008).

In short, reciprocity has the peculiar characteristic of combining dichotomies within the same behavior: generosity and self-interest, altruism and egoism, or freedom and obligation, which are not mutually exclusive, but rather coexist (Komter, 2007).

Social exchange theory suggests that both types of information exchange are directly related to positive reciprocity. Particularly within instrumental relationships, the information recipient will likely repay in kind in order to eliminate this debt (Clark, 1981) and thereby ensure the relationship's good health. We believe this especially holds true for the exchanges of novel information, regardless of the partner's institutional

² Earlier influential authors, such as Gouldner (1960) and Blau (1964), consider both positive and negative reciprocity. Negative reciprocity refers to retaliation measures taken in response to harmful acts previously carried out by the partner (Gouldner, 1960; Uhl-Bien & Maslyn, 2003). In this paper, we refer only to positive reciprocity.

affiliation. As mentioned above, the transfer of novel information does neither entail great effort nor significant material cost for the partners. Therefore, within this exchange actors will likely perceive that equivalence and immediacy are easy to attain.

Nevertheless, a reciprocal transfer of specific information is more difficult to achieve when partners belong to different institutional spheres. The relative value of this kind of information may likely differ from one institutional sphere to the other. The transfer of specific information often involves significant costs –financial, temporal and managerial– for the partners. The value of these resources may likewise vary from one institutional sphere to the other. Therefore, when partners belong to distinct institutional spheres, they will find it more difficult to agree on the value of the information given and received. Each actor needs to account for both the value of the costs incurred by the sender, as well as the value of the benefits received when repaying the exchange. Consequently, this equivalence feature of reciprocity may not be easily attained. Partners from the same institutional sphere face comparable conditions, and are therefore more likely to reach equivalent assessments of resource value within their exchanges. Based on the above, we posit the following hypotheses:

Hypothesis 5: Regardless of the partners' institutional affiliation, reciprocity will always be positively related to the access to *novel information*.

Hypothesis 6: When partners belong to the same institutional sphere, reciprocity will be positively related to the access to *specific information*.

4 Methods

4.1 Sample

Testing the hypotheses presented in the preceding section required a context where we could identify individuals who: (1) depend on their access to both types of information (novel and specific) to carry out their work, and (2) usually interact professionally with other actors from the same and other institutional spheres. For these reasons, we selected the field of academic research in nanotechnology. Nano-researchers focus on the development of technologies at the nano-scale (i.e. in the length of approximately 1–100 nm range); they thus require costly equipment such as clean rooms, extremely high-powered microscopes, powerful lasers, etc., that have to be obtained and operated in

collaboration with other researchers in academia, industry or government laboratories. Moreover, nanotechnology is an area of research where traditional disciplines merge — material science, molecular biology, chemistry and physics (Stix, 2001)— and where collaboration with other researchers has become essential (Islam & Miyazaki, 2009; Palmberg *et al.*, 2009)

Nevertheless, nanotechnology is a very broad and inclusive term with vague boundaries (Meyer *et al.*, 2004). Research in this field includes areas as diverse as medical applications, electronics, robotics, metrology, instrumentation, environment, etc. These areas of knowledge do not necessarily share a direct link, on the contrary, there is considerable cognitive distance between some of them (Meyer & Libaers, 2008), resulting in differing resource requirements and ways of collaborating with other actors.

To deal with such heterogeneity and obtain a controlled and homogeneous sample, we limited this study to the relationships maintained by scientists working in a specific, more homogeneous, sub-field: advanced materials at the nanoscale. The sample for this study included academics at state-funded research centers. We selected 11 research centers that had explicitly stated (via public reports or on their web site) that nano-materials represented their primary research activity; and had published through their website their researchers' names and e-mail address. We identified 866 individuals using this procedure.

4.2 Data Collection

We conducted a web survey among these nano-materials researchers. We had previously piloted a preliminary version of the survey instrument with 10 experts on organizational studies and innovation. The second version of the questionnaire was tested in March 2008 with 6 nanotechnology researchers from Spain and Holland who were not included in our sample. This second version underwent extensive qualitative pretesting that involved in-depth interviews with the 6 researchers. Each interview was approximately 30 minutes in length. We used feedback from the interviews to refine the wording of the questions, the scales of the answers and the overall presentation of the survey³. The survey was also designed and tested in both Spanish and English to address those researchers whose mother tongue was not Spanish.

³ See Annex A for the final version of the survey.

The survey was launched in April 2008. We also followed a variety of actions to elicit a higher response rate: a multiple contact strategy (prenotice e-mail message, e-mail with questionnaire, follow-ups and reminders), and the personalization of all e-mails and questionnaires (Dillman, 2007). We received 213 responses, which constituted a 25% response rate. From this group, we excluded incomplete cases and those respondents who did not report at least one tie with an external organization⁴. To reduce the probability of errors arising from the inclusion of researchers working in other nanotechnology sub-areas, we incorporated two qualifying questions to confirm that respondents were working on nano-materials.

Following these filtering stages, the final data set was comprised of 161 individuals: 33 full professors (20.5%), 79 associated scientists (49.1%) and 49 post-doctoral researchers and doctoral students (30.4%). These respondents reported a total of 594 ties with firms, governmental organizations and universities. Table 1 summarizes the relationships reported, by group.

TABLE 1: Final Sample

	Full Professors			Associated scientists			PostDocs/Docs			TOTAL		
	n.	%	Nr of ties per individual	n.	%	Nr of ties per individual	n.	%	Nr of ties per individual	n.	%	Nr of ties per individual
Firm	36	23.7	1.09	67	22.8	0.85	25	16.9	0.51	128	21.5	0.80
Governmental organization	38	25.0	1.15	87	29.6	1.10	50	33.8	1.02	175	29.5	1.09
University	78	51.3	2.36	140	51.3	1.77	73	49.3	1.49	291	49.0	1.81
TOTAL	152	100	4.61	294	100	3.72	148	100	3.02	594	100	3.69

4.3 Unit of Analysis and Measures

Unit of analysis: The unit of analysis is the interpersonal relationship between a researcher and his/her main contact at those organizations collaborating with the scientist. Thus, all the relations analyzed are manifestly positive, instrumental and external. The relevance of this unit of analysis is well justified throughout the literature. Scholars have found that the locus of control in scientific collaboration lies more on individuals than the organizations they represent, particularly when academic institutions

⁴ In order to increase the probability of reported contacts from other institutional spheres, we explicitly asked to exclude contacts from their own organization.

are involved (Liebeskind *et al.*, 1996; Bozeman & Corley, 2004). The know-how and information that researchers accumulate over time constitute their own knowledge stocks (McFadyen & Cannella Jr, 2004); consequently, the exchange of knowledge takes place primarily between people and within the context of personal relationships (Oliver & Liebeskind, 1997). Therefore, scientific collaboration is intrinsically a social process, where individuals, not organizations, are the key actors (Powell, 1990; Katz & Martin, 1997; Oliver & Liebeskind, 1997). This implies a complex, and dynamic interaction between the actors involved, less guided by formal structures of authority and more dependent on the relationship among individuals (Powell, 1990; Uzzi, 1996; Bozeman & Corley, 2004).

Dependent variables: We used two dependent variables—the access to novel information and specific information—. *Novel information access* is a one-item variable and detects if respondents' contacts supply them with information related to advances and discoveries in general. We asked respondents to indicate to what extent they agreed with the following statement about their main contact person at the reported organizations: “This person supplies me with information related to advances and discoveries in general”. *Specific information access* is another one-item variable and refers to the transfer of information adapted to the researcher's needs and supplied by their contacts. In a similar manner, we asked respondents to indicate to what extent they agreed with the following statement about their main contact person at the reported organizations: “This person supplies me with information adapted to my own research needs”.

We developed and refined the scales of both variables using feedback from the pretest interviews. Initially, a five-point Likert-type response format (from completely agree to completely disagree) was employed to define the scales of both variables. The final version included 4-point agree-disagree scales, with the middle term removed.

Independent variables: The independent variables addressed the qualitative characteristics of the personal ties contained in Granovetter's tie strength definition (*emotional intensity, mutual confiding, and reciprocal services*). According to Krackhardt (1992), there are two types of tie characteristics: quantitative and qualitative. The quantitative features refer to the amount of time in Granovetter's definition—i.e interaction frequency and years in contact—and are the objective aspect of the tie. The qualitative features of the tie refer to the other characteristics in Granovetter's

definition—i.e., intimacy, mutual confiding and reciprocity—and are inherently subjective and interpretive aspects of the tie, given they represent in some way the value that the relationship has for the actors.

The *degree of friendship* reflects the emotional intensity of a relationship (Gibbons, 2004). We considered that a friend is an individual who the respondent identifies as such. We asked respondents to indicate to what extent they agreed with the following statement: “I consider this person my friend” (where “this person” refers to the respondent’s main contact person at the other organization). The *degree of trust* refers to the mutual confiding aspect. We asked respondents to specify to what extent they considered his/her main contact person trustworthy. The *level of reciprocity* was constructed similar to Friendkin (1980), using two items: whether the researcher asked the main contact person for personal and professional advice and, conversely, whether the contact person asked the researcher for advice. The results were then averaged. This measurement underlines to what extent both individuals are proactive and their role in the relationship as both advice-seekers and advice-provider. The scales of all the items contained in these three variables were set to the five-point Liker-type (from completely agree to completely disagree).

Although no hypothesis was formulated concerning the relation between the amount of time (per Granovetter’s definition), the access to information and the partners’ institutional affiliation, two additional variables were included in our models: interaction frequency and years in contact. The first indicates the frequency of contact between the researcher and his contact. It is an ordinal variable with five categories ranging from weekly to yearly. *Years in contact* addresses the life span of the relationship. It is an ordinal variable containing five time ranges.

Control variables: We controlled for aspects that recurrently appear in the literature of innovation studies and university-society relationship. First, the models included attributes of the actors involved in the relationship. On the one hand, *respondents’ academic rank* and *type of research* were addressed with two dummy variables. The first, distinguishes between full professors, associate scientists and post-doctoral/doctoral researchers. The second classifies academics according to the type of research they conduct: pure fundamental, pure applied and a combination of fundamental and applied research. We also controlled for the contacts’ *geographical location* through another dummy variable which distinguishes if the contacts are regional, national or international.

Finally, we controlled for the formal collaborative activities the researchers carried out with their contact organizations. Thus, three dichotomous variables were created to check if both actors were collaborating through 1) *joint research or contract research agreements*, 2) *publications* or 3) *other activities* (consultancy agreements, creation of new facilities/spin-offs and training)⁵.

4.4 Analysis Techniques

We employed ordered logit regressions to analyze the data, using the Stata 11 software package. Robust estimators (Huber-White sandwich) were used to estimate standard errors. These estimators are considered robust because they provide correct standard errors in the presence of violations (e.g. heteroscedasticity) of the assumptions of the model (Long & Freese, 2001). Moreover, working with dyadic data can imply a violation of the assumption that the observations are independent. Since a single researcher can have relationships with different partners, our respondents were allowed to report multiple relationships. As a result, the error terms in the regression could be affected, given that they can be correlated across observations from the same source. To account for this, we used a *cluster* option in the estimation to indicate that the observations (relationships) were clustered into individuals. Therefore, the ties reported were possibly correlated within the responses given by one particular individual, but would remain independent between the 161 researchers. The *robust cluster* technique affects the estimated standard errors and variance-covariance matrix of the estimators, but not the estimated coefficients (Long & Freese, 2001).

5 Results

Table 2 displays the descriptive statistics, frequencies and Kendall's tau-b correlation coefficients of the total sample. In general, aggregated results show significant correlations between dependent and independent variables, as well as adequate correlation among the independent variables.

⁵ For further information see the questionnaire in Annex A.

TABLE 2: Descriptive Statistics and Correlation Coefficients^{ab}

<i>Variables</i>	<i>Mean/ Frequency</i>	<i>s.d./ %</i>	1	2	3	4	5	6	7	8	9
1. <i>Novel Information</i>	2.75	0.836									
2. <i>Specific Information</i>	2.90	0.762	0,59**								
3. Interaction Frequency	2.81	1.026	0,22**	0,26**							
4. Years in contact	3.55	1.166	0,14**	0,16**	0,08*						
5. Friendship	3.41	1.105	0,38**	0,34**	0,27**	0,35**					
6. Trust	4.00	0.862	0,39**	0,37**	0,23**	0,25**	0,58**				
7. Reciprocity	3.31	0.921	0,35**	0,34**	0,26**	0,24**	0,51**	0,41**			
8. Research Projects	514	86.5%	0,06	0,12**	0,06	-0,01	0,02	0,04	0,01		
9. Publications	345	58.1%	0,11**	0,19**	0,11**	0,23**	0,19**	0,18**	0,15**	-0,03	
10. Other Collaboration Activities	180	30.3%	0,04	0,01	0,07	0,08*	0,11**	0,08*	0,07*	-0,20**	-0,02

^a Non-parametric Kendall's tau-b correlation coefficients. Two-tailed test.

^b N = 594

**p < 0,01, *p < 0,05

Table 3 presents the results of the ordered logit regression models for the access to information. We report a total of 4 models: two for partners from the industry and government institutional spheres and two more for university partners (one model analyzes the access to novel information and the other the access to specific information). **Hypothesis 1** proposed that friendship is positively related to the access to novel information when the partner is from a different institutional sphere (i.e. firms and governmental organizations). This hypothesis is confirmed ($p < 0.01$). **Hypothesis 2** predicted no effect of friendship on accessing specific information, regardless of the contacts' institutional affiliation. Models 2 and 4 fully support this hypothesis.

TABLE 3: Results of Ordered Logit Regression on Information Access

Variables	Industry & Government				University			
	Model 1		Model 2		Model 3		Model 4	
	Novel Information		Specific Information		Novel Information		Specific Information	
<i>CONTROL</i>								
<i>Research Type</i>								
Basic	0.12	(0.33)	-0.08	(0.34)	-0.31	(0.36)	-0.32	(0.35)
Applied	0.09	(0.54)	0.42	(0.63)	0.67	(0.55)	0.73	(0.52)
<i>Academic Rank</i>								
Professors	-1.01*	(0.55)	-0.63	(0.50)	0.30	(0.56)	-0.07	(0.57)
Associate Lecturers & equivalent	-1.05*	(0.42)	-0.68[†]	(0.39)	-0.22	(0.49)	0.04	(0.47)
<i>Geographical location</i>								
Regional	-0.29	(0.34)	0.23	(0.31)	-0.89*	(0.37)	-0.33	(0.44)
International	0.53*	(0.31)	0.58[†]	(0.30)	-0.41	(0.35)	0.07	(0.35)
<i>Formal Collaboration Activities</i>								
Research Projects	0.21	(0.39)	0.99*	(0.38)	0.43	(0.41)	0.49	(0.43)
Publications	-0.25	(0.29)	0.23	(0.37)	0.08	(0.32)	0.37	(0.33)
Others	0.29	(0.33)	0.15	(0.34)	-0.38	(0.34)	-0.35	(0.31)
<i>TIE CHARACTERISTICS</i>								
Interaction Frequency	0.19	(0.13)	0.51**	(0.13)	0.28	(0.17)	0.27[†]	(0.15)
Years in contact	0.08	(0.12)	0.18	(0.14)	-0.04	(0.13)	-0.01	(0.15)
Friendship	0.65**	(0.21)	0.31	(0.19)	0.15	(0.22)	0.18	(0.23)
Trust	0.29	(0.19)	0.37*	(0.19)	0.73**	(0.28)	0.63**	(0.28)
Reciprocity	0.58**	(0.22)	0.38	(0.24)	0.23	(0.24)	0.32	(0.19)
# of observations (relationships)	303		303		291		291	
# of clusters (individuals)	128		128		129		129	
Log Pseudolikelihood	-330.9		-290.1		-290.8		-248.4	
Pseudo R ²	0.19		0.17		0.12		0.12	

**p < 0.01; *p < 0.05; [†]p < 0.1.

Hypothesis 3a and **3b** posited that trust only has a significant and positive effect on the access to novel information when partners in the relationship come from the same institutional sphere (no significant effect on the other cases was predicted). Both hypotheses are fully verified. Model 1 confirms no significant effect of trust on the access to novel information with partners from another institutional sphere (firms and governmental organizations). In the case of contacts from universities, trust has a significant and positive effect ($p < 0.01$). **Hypothesis 4** predicted a positive relation between trust and the access to specific information in all cases. This hypothesis is supported in the case of relationships with industry and government members ($p < 0.05$) as

well as in the case of university members ($p < 0.01$). **Hypothesis 5** suggested that, regardless of the contact's institutional affiliation, reciprocity is positively related to the access to novel information. This hypothesis only holds for the case of relationships with members from other institutional spheres. Therefore, we reject it given that, in the case of relationships with universities, reciprocity does not have a significant effect on the access to novel information. **Hypothesis 6** is also rejected. This hypothesis proposed a positive relationship between reciprocity and access to specific information, but only in those relationships with university members. Model 4 does not exhibit a significant coefficient for reciprocity.

It is also noteworthy to observe that the access to specific information always requires interaction frequency for the individuals to transmit it. This result is completely in line with the literature. In the context of scientific knowledge production and innovation, exchange partners need to expend effort to ensure sufficient mutual understanding (McFadyen & Cannella Jr, 2004) and that they can put into use the newly acquired knowledge (Hansen, 1999).

6 Discussion

The results suggest several relevant conclusions about the way in which the characteristics of social ties relate to the information that is exchanged through them. First, the difference between novel and specific information is significant: the exchange of different types of information places diverse requirements on the characteristics of the social link through which such information circulates. This means that the exchange of different types of information cannot be treated equally; in other words, a single measure of tie strength is not enough to explain how different types of information can be accessed. The traditional differentiation between strong and weak ties needs to be unbundled. Granovetter (1973) notably argued that strong ties would not favor the access to novel information. Instead we have found positive relations between the acquisition of novel information and the qualitative components of tie strength. Why do our results apparently contradict Granovetter?

Granovetter's Strength of Weak Ties Theory (1973) holds that links connecting two different institutional spheres (i.e., "bridge ties") are incapable of being strong. When developing his theory of strong ties, Granovetter only considers those relationships that

emerge in a natural manner between socially similar individuals: homophilious relationships evoked by expressive actions. He focuses his argument on friendship networks and assumes explicitly—and “*by definition*” (pp. 1362)—that a strong link always implies great commitments of time. At the same time, he assumes that individuals linked through a strong tie physically interact (pp. 1362), since a link’s strength depends on individuals spending a lot of time together. Consequently, in order for these physical meetings to be realized with the theoretical frequency demanded by a strong link, geographical distance should be small; otherwise it would obstruct the interaction between the actors.

Implicitly, Granovetter only considers as “strong” those links that are the product of an intense and continuous social interaction. By extension, only two types of links exist for Granovetter: links positioned at the positive extreme of the continuum of the tie strength (strong ties), and the rest (weak ties). Consequently, heterophilious relationships, from the point of view of Granovetter, would always be relationships characterized by the existence of a weak tie as, and by definition, they connect dissimilar actors and therefore that tie can never be strong. The homophily principle, in which Granovetter bases his thesis, relies on the assumption that socially similar individuals, even when acting in their own interest, spend time together in the same place (Homans, 1950; Granovetter, 1973; Burt, 1992). For this reason, relationships emerge naturally, forming clusters of people with similar tastes, lifestyles, and resources. Therefore, from this viewpoint, it is impossible that strong links can connect two different institutional spheres.

However, when relationships between individuals do not arise in a spontaneous manner, but rather occur as a consequence of actors’ intentional collaboration with the aim of achieving a specific goal –i.e., instrumental actions–, social similarity among agents is no longer predetermined; quite the opposite: they join forces with the intention of accessing resources to achieve either a shared or complementary goals. This does not prevent them, as the results of this study verify, from developing a strong tie between them while remaining in their respective institutional sphere (for instance, the strong ties we identified between researchers and individuals working in firms or government organizations). In fact, as Mayer *et al.* (1995) point out, trust creation (one of the tie-strength indicators), can be built by other means apart from social similarity. Consequently, in this case the strength of a tie will not be initiated by homophily principles.

The majority of bridge ties between two institutional spheres are likely to start as weak links. We do not argue against this aspect. However, part of the quality of those bridges varies to the extent that some of them trespass the barriers of institutional distance, becoming strong. When this happens such distance is transformed from a barrier to the development of relationships to an enhancer because it offers the agents involved in the link access to a broader variety of resources.

When individuals seek out resources from other institutional environments, the chances of accessing them are greater if they are capable of contacting and developing a strong tie with other amenable individuals (though, not socially similar as the homophily principle predicts). The success of this relationship hinges on the degree of affinity between the two actors: the compatibility of their objectives, the degree to which each approves of the norms of the other's institutional sphere, etc. This affinity is more difficult and costly to build when the actors are dissimilar; yet, the potential benefits are very high as the link allows access to new resources and, through its strength, affords opportunities to use them (Burt, 1992).

The heterophilous relationships that develop into strong links can be explained by unbundling the notion of the strength of a social link into three elements: friendship, trust and reciprocity. We have shown how the logic of the exchange of novel information varies with the institutional location of the individuals involved.⁶ For instance, when two university researchers exchange novel information, trust is a key element in the relationship; trust may be important because when researchers ask for information to other scholars they become vulnerable in terms of reputation (Levin & Cross, 2004) as the request may indicate a lack of competence. Importantly, trust does not emerge as a relevant feature of the relationship when novel information is exchanged across institutional boundaries; in this situation, friendship and reciprocity characterize the link. As explained in the development of the hypotheses, trust is an expensive way to build a social links, and agents may draw on it only when necessary, i.e. when the exchange of information may indicate vulnerability or be conducted under of uncertainty. The friendship-base access to novel information across institutional boundaries may be indicating a benevolent exchange behavior in the interest of the relationship.

⁶ This is in line with Silverman and Baum (2002), who point that exchange behavior within cooperative relationships are contingent on the type of partner. That is, relations with different institutional actors result on different types of behaviors.

Additionally, when academics exchange information with these actors some kind of immediate return may be required by the partners: both sides of the relationship will act in a calculating manner and only if a mutual benefit is expected.

Finally, the logic of exchange when accessing specific information is different. Specific information implies the acquisition of detailed information about the partner's activities, capacities, intentions and objectives (Uzzi, 1997; Rowley et al., 2000). In short, actors are able to obtain knowledge about their partners' core competences and other important intangible assets. We identify three possible reasons for the exchange of specific information to be based on trust: (1) the tension between acquiring new knowledge and the fear of possible acts of plagiarism or the potential risk of knowledge spillover, (2) the possible existence of weak formal institutions that regulate exchange between researchers and other agents, given that "where institutional supports are weak, personal relationship and trust play a more prominent role" (Zaheer & Zaheer, 2006: 23), (3) the existence of interdependency between partners; the need of trust increases with the level of interdependency (Wicks & Berman, 2004). In any of the aforementioned situations trust becomes a fundamental norm for the exchange to take place.

Annexes

A. Survey.

(1) We currently have the following information about you. If necessary, please provide any changes in the section below:

Name: [!NAME!] [!SURNAME!]

Research Group: [!RESEARCH GROUP!]

Research Centre: [!RESEARCH CENTER!]

(2) Gender:

- Male
- Female

(3) Please indicate which position you hold at your institute:

(Please indicate the option that most closely matches your actual position)

- Full professor
- Associate professor
- Assistant professor
- Postdoc
- Ph.D. student
- Other (please specify)

(4) Which of the following features characterises your research most accurately?

(Please select all those that apply)

- Research and development at the atomic, molecular or macromolecular levels, in the length scale of approximately 1–100 nanometer range.
- It provides a fundamental understanding of phenomena and materials at the nanoscale.
- It attempts to create and use structures, devices and systems that have novel properties and functions because of their small and/or intermediate size.
- It attempts to control and manipulate on the atomic scale.
- My research does not fit any of the above features.

(5) To which of the following areas could your research be applied?

(Please select all those that apply)

- Materials
- Medical applications (diagnostic and therapeutic)
- Nano–electronics (–photonics, –magnetism) and information elaboration processes
- Energy production and storage
- Metrology and development of instruments
- Food, water and environment
- Manufacturing processes
- Security and defense
- Robotics
- Other (please specify)

(6) Do you have contacts with ORGANIZATIONS including firms, governmental agencies and institutions, academic organizations, etc. with which you have interacted in connection with your MAIN research?

Please exclude your own research institute or centre, [!RESEARCH CENTER!].

- Yes
- No > End questionnaire

(7) (8) (9) Please give the names or abbreviation of the principal ORGANISATIONS, including firms, governmental agencies and institutions, academic organizations, etc. with which you have interacted during the last two years in connection with your MAIN research.

Please exclude your own research institute or centre, [RESEARCH CENTER!].

In the following part of the questionnaire we will ask you questions related to the *organizations* reported here

	(7) Name or abbreviation	(8) Indicate the type of organization	(9) Indicate the geographical location of your contact
Organization 1	XXX	Private firm	Regional
Organization 2	YYY	Governmental agency or organization	National
Organization 3	ZZZ	Academic or research institution	International
Organization 4	VVV	Other	
Organization 5	JJJ		

(10) In which of the following types of activities have you been engaged with the ORGANIZATIONS you have just reported? (Please select all those that apply)

NOTE:

– *Training*: refers to training this organization employees and/or postgraduate training in the organization (e.g. joint supervision of PhDs).

– *Consultancy agreement*: refers to work commissioned by this organization, which does not involve original research, e.g. conducting routine test,

providing advice, etc.

– *Joint research or contract research agreement*: refers to original research work done by both partners or University alone.

	Training	Consultancy agreement	Joint research or contract research agreement	Joint-authored presentation to conference, paper and other documents	Setting up the organization or creation of new physical facilities (e.g. new laboratory, other buildings on campus, etc.)	Other (Please specify)
XXX						
YYY						
ZZZ						
VVV						
JJJ						

(11) (12) (13) (14) (15) (16) (17) (18) The following questions refer to your MAIN CONTACT PERSON in the organizations you have just reported. Please fill in the table below.

	(11) How often do you communicate with this person? (e.g. phone calls, mails, meetings, etc.)	(12) How long have you known this person?	(13) This person supplies me with information related to advances and discoveries in general	(14) This person supplies me with information adapted to my own research needs
XXX	Daily	<1 year	Strongly disagree	
YYY	Weekly	1–2 years	Disagree	
ZZZ	Monthly	3–5 years	Agree	
VVV	Quarterly	6–10 years	Strongly agree	
JJJ	Yearly	>10 years		

	(15) I consider this person my friend	(16) I ask this person for personal or professional advice	(17) This person asks ME for personal or professional advice	(18) I consider this person trustworthy
XXX	Strongly disagree			
YYY	Disagree			

ZZZ	Neutral			
VVV	Agree			
JJJ	Strongly agree			

B. Kendall's tau-b correlation matrixes.

Table 4: Relationships with firms and governmental organizations, N=303

	(1)	(2)	(3)	(4)
(1) Interaction Frequency				
(2) Years in contact	0,036			
(3) Friendship	0,246**	0,348**		
(4) Trust	0,213**	0,261**	0,562**	
(5) Reciprocity	0,270**	0,213**	0,523**	0,429**

**p< 0,01

Table 5: Relationships with universities, N=291

	(1)	(2)	(3)	(4)
(1) Interaction Frequency				
(2) Years in contact	0,125*			
(3) Friendship	0,295**	0,323**		
(4) Trust	0,253**	0,207**	0,583**	
(5) Reciprocity	0,240**	0,239**	0,477**	0,382**

**p< 0,01, *p< 0,05.

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