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Regions Matter: How Regional Characteristics Affect External Knowledge Acquisition and Innovation

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Abstract:
To introduce new products and processes, firms often acquire knowledge from other organizations. Drawing on social capital and transaction cost theory, we argue that not only is the impact of such acquisitions on the successful development of product and product innovations dependent on strategic and economic variables, it may also be contingent on the "knowledge characteristics" of the geographical area in which the firm is located. Combining data on social capital at the level of 21 regions with a large scale data set on innovative activities by a representative sample of 2464 Italian manufacturing firms, we find — after controlling for a large set of firm and regional characteristics — that being located in regions characterized by high levels of social interaction leads to a higher propensity to innovate. In addition, being located in an area characterized by a high degree of social interaction positively moderates the effectiveness of externally acquired R&D on innovation inclination.

Key words: Social capital; external acquisition; process innovation; product innovation
Jel codes: L23;O31

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1. Introduction

Although the importance of external sources — e.g., users, suppliers, competitors, universities etc. — for innovation is not new, up until recent years most firms have conducted research and development (R&D) activities predominantly in-house. Recently, however, in a large number of industrial sectors, purchases of technology licenses and outsourcing of R&D processes have increased, reflecting the emergence of a more fine-grained division of labor (Arora et al. 2001; Cassiman and Veugelers 2006; Sobrero and Roberts 2001). In other words, some organizational decisions related to R&D activities become "make" or "buy" decisions. Extant literature has focused on the extent to which external R&D is complementary to internal R&D (Cassiman and Veugelers 2006) and on the propensity to license technologies (Arora and Ceccagnoli 2006) and has provided extremely valuable insights to understand this process. Research, however, has not yet examined important contingencies that allow firms to outsource stages of the R&D process. One such contingency is the "knowledge characteristics" of the region where firms are located.

There is ample evidence to suggest that knowledge flows are geographically bound as they tend to stream through social networks (e.g., Almeida and Kogut 1999; Gambardella and Giarratana 2007; Powell and Owen-Smith 2004; Sorenson 2003; Tallman et al. 2004). We follow Romanelli and Khessina (2005) and assume that "within regional boundaries, frequent interaction promotes the exchange of information of situations and events that participants in the exchange commonly experience" (p. 347). The central argument of this paper is that social capital can be considered a geographically bound public good that reduces both search costs between firms and between firms and other organizations and transaction costs involving decision and verification costs, thereby easing learning opportunities for innovation. The paper draws on social capital and transaction cost theory in examining the importance of regional social capital for firms' innovative capabilities to introduce process and product innovations, and explains how social capital moderates the effectiveness of externally acquired R&D for innovations.

A contentious issue is how to conceptualize and measure social capital. In the existing literature, social capital is often seen as a multidimensional entity encompassing the existing stock of social relationships in a society in the form of networks and other social relationships, shared norms and understandings. More specifically, here we follow Coleman in seeing social capital as an entity that "… is defined by its function. It is not a single entity, but a variety of different entities, with two elements in common: they all consist in some aspect of social structures, and they facilitate certain actions of actors within the structure" (Coleman 1988: 98). However, while Coleman and other social capital theorists have emphasized the role of intra community ties, Burt (1992) accentuated the (favorable) absence of strong ties, since in his view, dense networks transmit redundant information, while weaker ties can be sources of new resources and knowledge. Here, we follow Woolcock and Narayan (2000: 231) in advancing the claim that the logical conclusion of this debate is that "both strong intra community ties and weak extra community networks are needed to avoid making tautological claims regarding the efficacy of social capital." In other words, our concept of regionally bound social capital contains both "closure" as well as "bridging" network ties. The problem with empirical research on social capital is, however, the lack of a clear distinction between sources and consequences of social capital (Portes and Landolt 1996). In this regard, Nahapiet and Ghoshal (1998) and Lindenberg (1996) are helpful in distinguishing between the structural and relational dimensions of social capital. The structural dimension refers to informal social interactions amongst individuals that generate cooperation and coordination and reduce opportunistic behaviors. The relational dimension refers to the assets rooted in those relationships (e.g. trust and trustworthiness). We consider the structural dimension to be the most suitable for empirical analysis because it focuses on the sources of social capital as distinct from its consequences.

Empirically, we exploit within-country regional variation to investigate the effects of social capital on innovation. We use Italy as our reference point since that setting is an interesting "test-case", as Italian regions are very different in terms of the availability of social capital. Italy has historically been central in the social capital debate as it has constituted the empirical focus of prominent sociologists studying the effect of social capital (Banfield 1958; Putnam et al. 1993). We combine data on social capital at the level of 21 regions with a large-scale data set on innovative activities in a representative sample of 2464 Italian manufacturing firms to analyze the effect of social capital on both product and process innovation, as the implications of social capital may differ according to the type of innovation. Following Schumpeter (1912/1934), we define product innovation as new combinations of knowledge being exploited to produce commercially viable goods. Following Tushman and Nadler (1986: 76), we understand process innovation as "a change in the way products are made or delivered" with the aim of achieving lower costs and/or higher product quality.

We find that being located in regions characterized by a high level of social interaction leads to a higher propensity to innovate. This result holds after controlling for a large set of firm and regional characteristics. We find, however, that political participation — another important dimension of social capital — does not affect innovation. In addition, we find that social capital represents an external contingency that positively affects external sourcing of R&D; that is, being located in an area characterized by a high degree of social interaction positively moderates the effectiveness of externally acquired R&D on innovation.

The paper is organized as follows. In Section 2, we illustrate and discuss existing literature on social capital and its main implications for economic outcomes. Section 3 presents the hypotheses. Sections 4 and 5 present the data and the measures of social capital, respectively. In Section 6, we explain the method and the results of the empirical analysis. Section 7 concludes the paper.

2. Empirical and theoretical background

Research has focused on the role of social capital in different empirical contexts, ranging from individuals and small groups (e.g., Moran 2005) to larger organizations and inter-firm alliances (e.g., Gulati 1995; Nahapiet and Ghoshal 1998; Tsai and Ghoshal 1998), through cities (e.g., Jacobs 1961) and regions (e.g., Beugelsdijk and van Schaik 2005; Cooke et al. 2005; Maskell 2000; e.g., Putnam et al. 1993) to entire nations (e.g., Knack and Keefer 1997; Zak and Knack 2001). This paper focuses on regional social capital.

The importance of social variables to explain economic outcomes has a long tradition. Long ago, Banfield (1958) argued that Southern Italy's economic backwardness was due to the lack of social capital. Later, Putnam et al. (1993) found that the performance of Italian social and political institutions was strongly influenced by citizens' engagement in community affairs, i.e. by social capital. Putnam et al. (1993) viewed memberships of horizontal associations as fundamental for the cooperation and communication among their members and also saw them as a source of generalized trust and social ties, conducive to economic performance and governmental efficiency. After Putnam et al.'s (1993) study, research on the relationship between social capital and economic outcomes flourished (Nahapiet and Ghoshal 1998).

Empirically, Knack and Keefer (1997) conducted a cross-country analysis and showed that trust and civic norms have been related to economic performance in 29 market economies over the last twenty-year period. Recently, Guiso et al. (2004) studied the importance of social capital on financial development and showed that in Italian regions with higher levels of social capital, householders are more likely to use checks, invest more in stocks, and have higher access to informal credit. Beugelsdijk and van Schaik (2005) found that social capital correlates with high levels of economic growth for a sample of 54 European regions. Although research on the relationship between social capital and economic outcomes has flourished, studies relating social capital to firm-level innovation are still scant. One notable exception is Landry et al.'s (2002) study. They provide evidence that diverse forms of firm-level social capital — understood as participation and relational assets — contribute more than any other explanatory variable to increase the likelihood of introducing an innovation. However, while the focal point of that study is that of a region in Canada, the social capital measures are those perceived by firms, not measures directly linked to the regional *milieu*.

Hypothesis

Regional social capital and innovation

The role of networks, communities, and interdependence has come to the forefront in investigations of firms' innovative activities. The early Schumpeterian idea of the solitary entrepreneur bringing about innovations has been overtaken by a representation involving different actors working together in iterative learning processes of trial and error (Freeman and Soete 1997; Pavitt 2005; Rosenberg 1982; Schumpeter 1942/87; von Hippel 1988; Walker et al. 1997). Innovation increasingly requires the simultaneous use of a variety skills and knowledge, and these skills and knowledge may not be found within the boundaries of the firm (Rosenberg 1982). Accordingly, innovators seldom innovate alone. These newer conceptualizations of innovation highlight that interactive learning is central to the innovation process, suggesting that innovators rely on formal and informal knowledge trading with a range of institutions and actors within an innovation system that includes lead users, suppliers, universities (Brown and Eisenhardt 1995; Lundvall 1992; Szulanski 1996; von Hippel 1988), and also competitors (Arora et al. 2001; von Hippel 1987). Recently, Chesbrough (2003) labeled this distributed nature of the innovation process as "open innovation".

The general hypothesis developed in this paper is that high levels of social capital in the home region may help generate firms' competitive advantages since social capital favors information and knowledge exchange for innovation. The information benefits central to the first stage of the search process for innovative solutions consist of access, the opportunity to obtain a valuable piece of information; of timing, the opportunity to be informed early; and of referrals, having your name mentioned at the right time in the right place (Burt 1992). Following Granovetter (1973), Burt (1992) argued that the strength of weak ties stems from the opportunity that these ties may offer to bridge otherwise disconnected groups of actors. These connections may lead to non-local or boundary spanning search, which has been considered a necessary requirement for successful innovations (Fleming and Sorenson 2001; Rosenkopf and Nerkar 2001). Localized social networks may ease the process of such external knowledge search through a richer set of communication channels (Sorenson 2003).

Innovation can be defined in terms of new combinations of existing knowledge (Fleming and Sorenson 2001; Kogut and Zander 1992; Schumpeter 1912/1934). Accordingly, since variety of knowledge is key to the process of generating new combinations (Metcalfe 1994), in a second phase, external search helps organizations plug into external sources of variety (often through collaboration), allowing them to create innovations based on new combinations of technologies and knowledge (Laursen and Salter 2006). However, since innovation projects involving external parties are beset with information asymmetries, potential moral hazard problems must also be taken into consideration (Pisano 1990;

Williamson 1979). Regional social capital may reduce transaction costs involved in open innovation projects, including decision and verification costs (Maskell 2000). Since firms invest in verifying the truthfulness of the claims made by external actors (Zak and Knack 2001), high levels of social capital make the situation more transparent for the decision maker and decision making easier and less costly. As a consequence, resources otherwise spent on verification may be invested in other economic activities, including innovative ones. Social capital reduces such verification costs through the reduction of information asymmetries and based on the establishment of trust-based relationships, since trust is facilitated by repeated social contacts (Gulati 1995) implied by high levels of social capital. In sum, we hypothesize:

H1: Firms located in regions characterized by high levels of social capital are more likely to introduce product and process innovations.

Social capital and external R&D

Outsourcing of R&D enables firms to tap into specialized sources of knowledge and capabilities (e.g., Dyer and Ouchi 1993; Leiblein et al. 2002; Mowery et al. 1996; Sobrero and Roberts 2001). External sourcing of R&D may be affected by regional social capital, a contingency that may influence the effectiveness of the externally acquired R&D in producing innovations. R&D projects involve asset-specific investments and are complex, and as a consequence, related contracts are hard to define *ex ante* (Arora et al. 2001), so the risk of hold-up is eminent (Oxley 1997; Pisano 1990; Williamson 1979, 1985). However, social capital may work as an institutional “reparation mechanism” of the implied market failure, facilitating a solution to the transaction cost problems. Search, decision, and verification costs will be lower with high levels of regional social capital when taking make and buy decisions with respect to external R&D acquisitions. Successful outsourcing may also require related outsourcing experience, involving processes of trial and error. Operating in a geographical region with a high level of social capital may provide better opportunities for learning how to deal effectively with the management of outsourcing of R&D activities, since such an environment is conducive to working with external actors, and therefore, prior related experience is much more likely to have been accumulated. These arguments lead us to state the following hypothesis:

H2: The effect of externally acquired R&D on the likelihood of introducing product and process innovation is greater for firms operating in regions associated with high levels of social capital

Social capital and product and process innovation

Product innovation involves the creation of technologically new products, whereas process innovation involves new elements introduced into an organization's production or service activities in terms of task specifications, work and information flow input factors, and machinery used to manufacture a product or deliver a service (Abernathy and Utterback 1975; Freeman and Soete 1997; Rosenberg 1976; Tushman and Anderson 1986). Product innovation requires extensive processes of explorative search and interaction with many different internal and external sources of knowledge (Brown and Eisenhardt 1995). In contrast, process innovation has been described by Tushman and Rosenkopf (1992: 313) as "the most primitive form of innovation" and typically requires less search outside the organization. Process innovations are often the result of learning-by-using and learning-by-doing, as a consequence of the organization's experience of using new technology (Hatch and Mowery 1998; Rosenberg 1982). Accordingly, process innovations are the outcome of managerial decisions about how best to organize the firm to optimize the efficiency of its internal procedures and routines. As a result, process innovations are often not licensed or sold to other organizations (Arora et al. 2001). Moreover, given the difficulties in defining process innovations precisely, secrecy is in general more effective to protect the return from process innovation rather than product innovation (Cohen et al. 2000; Levin et al. 1987). Obviously, the role of secrecy reduces the scope for external interaction in the innovation process. In sum, these arguments lead us to conjecture:

H3: Regional social capital increases the likelihood of firms introducing product innovation more than process innovation.

Since product and process innovations are often complementary (Pisano 1996; Reichstein and Salter 2006) they are frequently introduced simultaneously. In other words, a product innovation may very often require a new process technique in order for it to be technologically and commercially successful. The concurrent introduction of the two types of innovation is a complex and costly process, however. Due to resource constraints, such complexity may induce firms to rely more on external sources of innovation (Arora et al. 2001), making the importance of social capital especially pertinent. Accordingly, we hypothesize:

H4: Firms operating in regions associated with high levels of social capital will be more likely to introduce product and process innovations simultaneously.

Data description

This research uses variables referring to two different levels of analysis: firm and region. Consequently, the data come from different databases. Regarding the firm level, data on innovation in Italian manufacturing firms have been collected by Capitalia (an Italian Bank Group) from a stratified random sampling frame of manufacturing firms with more than 10 employees (Capitalia 2006). The survey refers to the three-year period 2001-2003 and the sampling plan was created by subdividing the population of the assigned firms into layers (strata). The population from which the sample was extracted consists of approximately 70,000 firms. The proportion of the sampling frame out of the population is 7 percent in terms of the number of firms, and 9 percent in terms of the number of employees. The survey was carried out using a questionnaire instrument, through telephone interviews, and obtained a response rate of 28.5 percent. The sample obtained has been found to be representative of Italian manufacturing firms across four macro regions (i.e. northwest, northeast, center, and south), Pavitt's (1984) sectors (i.e. supplier dominated, scale intensive, science based, specialized suppliers) and firm size (11-20, 21-50, 51-250, 251-500, more than 500 employees) (Capitalia 2006). The actual number of observations, without missing values for all our variables, includes 2464 firms.

With regard to the regional level, the data used to analyze structural social capital have been collected by the Italian National Institute of Statistics (ISTAT) through Multi-scope Analyses carried out in 1999. The survey was compulsory and was carried out through telephone interviews. The resulting response rate was 82.5 per cent. The individual responses have been aggregated by ISTAT to the level of the 21 regions. To validate the geographical unit of analysis (the 21 regions) against the alternative, the Italian provincial level (a total of 100 provinces are located within a region with at least two provinces), we conducted a components of variance analysis with random effects (see for instance, McGahan and Porter 1997) for three variables — that may be related to geographical structural social capital — that we have available at the provincial level as well: 1) per capita GDP for 2001; 2) participation rate in the 2001 referendum on institutional reform; and 3) per capita legal protests for the lack of payment of obligations for the year 2001. For these three variables we found that the regional level accounts for between 68 to 77 percent of the total variance, while the provincial level accounts for between 18 and 26 per cent (the residual accounts for between 5 and 6 percent). Accordingly, we believe that the level of the 21 Italian regions is the most relevant level of aggregation for our purposes, since variation in social capital levels is likely to predominantly between, rather than within, regions. To measure regional expenditure on R&D as the percentage of regional GDP, regional human capital and the size of the population, we use data obtained from the European Community's (EC) statistical office, EUROSTAT. The units identified are the regions corresponding to the Nomenclature of Territorial Units for Statistics level 2 (NUTS 2), the classification adopted by the EC.

We avoid the problem of common method bias to some extent, since our dependent variables are collected at the firm level, while some of the key independent variables (in particular those related to social capital) are collected at the level of the individual person and aggregated up to the NUTS2 regional level. For the firm-specific variables, the questions underlying the outcome variables were placed after the questions underlying independent variables on the survey in order to diminish, if not avoid, the effects of consistency artifacts (Salancik and Pfeffer 1977). Moreover, we performed Harman's one-factor test on the firm-level variables included in the models presented in this paper, to examine whether common method bias may augment the relationships detected. Since we found multiple factors, and since the first factor did not account for the majority of the variance (the first factor accounts for only 18 percent of the variance), potential problems associated with common method bias were not indicated by the test (Podsakoff and Organ 1986).

The structural social capital measure

Following the mainstream sociological research on social capital (e.g., Coleman 1988; Portes 1998; Putnam et al. 1993) — and as pointed out in the introduction — we focus on the structural dimension of social capital. The structural dimension is also considered the most suitable for empirical analysis, because it is much easier to measure accurately. To measure structural social capital of the Italian regions, we selected a total of 11 regional social capital variables. Table 1 reports on the meaning of each of the social capital variables. We consider variables representing friendship and spare-time socialization (*WEFRI, SOPAR, SAFRI*), participation in social associations (*CULAS, VOLAS, NVOAS, NUMAS, MONAS*) and political participation (*POPART, MONPA, COMI*). In accordance with our adopted concept of social capital, the two former types of variables represent coexisting intra community (exclusion) ties and weak extra community network (bridging) ties. With respect to the latter set of variables, Scaff (1975) underlines that two distinct concepts define political participation; participation as interaction, or participation as an instrumental action. The former is closely associated with the idea of cooperation and reciprocity to promote communication and the achievement of common interests; the latter refers to participation as an instrument to obtain personal advantages, in turn generating competition for resources.

[Insert Table 1 about here]

We run a non-parametric principal component analysis (PCA) on the social capital variables. The non-parametric principal component analysis differs from the standard PCA since it deduces eigenvalues from a co-graduation matrix (Spearman's rho or rank order correlation coefficients). The aim is to minimize the effect of outliers. Appendix Table 1 reports the eigenvalues and the percentage of variance explained by the two components. Table 2 displays the two principal components that we extract from the analysis. The two components explain more than 80 percent of the total variance. This is considered a very satisfactory result for the analysis of social variables. The first factor appears to capture “social interaction” and the second factor appears to capture “political participation.”

[Insert Table 2 about here]

Econometric analysis

Measures

Dependent Variables. The dependent variable in the first logit analysis is a dummy variable, describing whether or not firms introduced product innovation, with 1 being product innovative and 0 being non-product innovative. In a second logit model, the dependent variable is a dummy variable measuring whether or not firms are process innovative, with 1 being process innovative and 0 being non-process innovative. The two variables are based on the following question: "Over the three year period 2001-2003, did your firm introduce? a) product innovation; b) process innovation. For product innovation, we mean the introduction of at least one new product (or a significantly improved one), and for process innovation, we mean the adoption of at least one new process (or a significantly improved one)." Process and product innovation were not mutually exclusive on the survey. For the multinomial logit analysis, we compare firms realizing neither product nor process innovation (A) to firms which are product innovative only (B); process innovative only (C); and to firms both product and process innovative (D). Table 3 shows the categories and the numbers of observations for each category.

[Insert Table 3 about here]

Independent Variables. Two of the key independent variables are the factors representing the principal components of social capital at the regional level: social interaction (S*ocial capital I* — *social interaction*) and political participation (*Social capital II* — *political participation*). The final key independent variable is a firm-level variable representing *external R&D acquisition*, which is captured by the percentage of externally acquired R&D as a percentage of the firm's sales.

Firm specific control variables. Although empirical research indicates that the advantages of size for innovativeness are ambiguous, size is commonly used as a variable in firm-level studies of innovation (Cohen 1995). On the one hand, larger firms may have higher market power or may be favored by economies of scale and scope, and thus they may be able to raise the profitability of innovation strategies; on the other hand, smaller firms are more flexible and they have fewer bureaucratic problems, which may increase their innovation process efficiency. We measure firms' *size* by the number of employees. Further, we control for *R&D intensity*, measured by the fraction of sales spent on R&D, as well as for firms' *age*. The *percentage of employees with a degree* measures the human capital of the firm. The principal activities of firms is measured by four dummies *(supplier dominated, scale intensive, science based, specialized suppliers)* representing the Pavitt (1984) sectors. Additionally, since the innovation literature has shown attention to user's needs is important to innovative success (Pavitt 1984; von Hippel 1988), we use a dummy variable to describe firms' strategies to use *customer satisfaction*.

Regionally specific control variables. The region specific characteristics influencing innovation include the (public and private) *regional expenditure on R&D* as the percentage of regional GDP, as well as the percentage of the workforce with a science and technology degree to measure the *regional human capital* of the region. The *population* variable is captured by the number of residents in a given region.

Table 4 gives descriptive statistics and correlations among our variables. The correlations are generally low, apart from the correlation (r = 0.47) between *regional human capital* and s*ocial capital I – social interaction.* However, since the results are robust to dropping any of the two variables, we do not appear to have multicollinearity problems.

[Insert Table 4 about here]

Regression analysis

Means of estimation

Since our dependent variables (product/no product innovation; product/no process innovation) are binary variables, we apply a logit model as the means of estimation. As we are also interested in the joint introduction of process and product innovation (in particular to asses Hypothesis 4), we also estimate our models using a multinomial logit model. However, we have an endogeneity problem, since we must take account of the fact that management's anticipations in relation to performance outcomes as a result of the strategy chosen can lead to biased coefficient estimates. This is the case when using a single equation logit model, not correcting for endogeneity (Hamilton and Nickerson 2003). These biases may stem from omitted variables related to management's self-selection, which affects both the choice to make or buy R&D and innovation outcome (see, Wooldridge 2002: 50-51).

It is possible to eliminate the endogeneity bias through an instrumental variables (IV) regression approach since the chosen instruments from the first stage model must not be correlated with the unobserved variable representing managers' self-selection in the second stage of the model. As we have a dependent variable in the first stage, with a lower and an upper bound (fraction of acquired R&D over total sales), the fractional logit regression may be applied (Papke and Wooldridge 1996). In this approach, $E(y \mid \mathbf{x})$ is modeled as a logistic function, where y is the dependent variable and $\mathbf{x}$ is a set of regressors: $E(y \mid \mathbf{x}) = \exp(\mathbf{x}\boldsymbol{\beta})/[1 + \exp(\mathbf{x}\boldsymbol{\beta})]$. The model ensures that the predicted values of y are in (0, 1) and that the effect of any x_j on $E(y \mid \mathbf{x})$ diminishes as $\mathbf{x}\boldsymbol{\beta} \to \infty$. We use the predicted values from this first stage part of the model in lieu of the observed values of external R&D acquisition in the second stage equation.

Apart from being correlated with the model's endogenous regressor, the instruments must not bear the same problem as the original regressor (Wooldridge 2002: 105). This leaves a problem in finding suitable instruments. Here we use four instruments that can be conjectured to condition external R&D acquisition, but not the propensity to innovate. These variables measure: 1) whether or not the firm is a *member of a commercial consortium*; 2) whether or not the firm is a *member of a corporate group*; 3) whether or not the firm has previous experience in markets for technology in terms of having *acquired patents*; and 4) *average industry-level R&D intensity*. The latter is measured for 96 industries, where the industries are classified according a mixture of two and three-digit industry codes (aggregated so that at least five firms appear in each industry). This variable may reflect the appropriability regime that the given firm is operating under (Cohen and Levinthal 1990; Levin et al. 1987; Teece 1986).

As required, all our instruments in the first-stage regression model correlate (see Appendix Table 2) with the variable they instrument for (external R&D acquisition). Since we are using a fractional response logit - logit specification, we have no perfect test of the validity of the instruments. The probit model with endogenous regressors, however, allows for testing the validity of instruments. Therefore, to understand the validity of the instruments better, we use an instrumental variable probit estimation of our equations, although this means of estimation leads to biased coefficients (since in the first stage, the dependent variable is assumed to be continuous). The joint null hypothesis is that the group of instruments are valid instruments, that is, they are uncorrelated with the error term in the structural equation, and the excluded instruments are correctly excluded from the estimated equation. With the four aforementioned instruments for external R&D acquisition, the Amemiya-Lee-Newey minimum chi square test statistic is 2.35, with a corresponding *p*-value of 0.50 (calculated using the ivprobit and overid modules for Stata) for product innovation. In other words, we cannot reject the null hypothesis (we find a similar result for process innovation). A Wald test for exogeneity rejects the idea that the acquisition of external R&D is exogenous in determining the probability of being a product innovator at the ten percent level, while we are able to reject the null hypothesis of exogeneity for process innovation at the twenty percent level. Hence, since the latter statistic is only weakly consistent with exogeneity, we will treat the acquisition of external R&D as endogenous when considering process as well as product innovation.

Results

The results of the logit estimations for the second stage of the procedure are reported in Table 5. We find support for Hypothesis 1 ("Firms operating in regions associated with high levels of social capital will be more likely to introduce product and process innovation"), to the extent that the social interaction component of social capital is significant in explaining the likelihood of introducing product and process innovation.[1] The result for process innovation is significant at the five percent level only. Political participation did not provide support for product innovation or for process innovation. This may be due to the fact that two distinct concepts define political participation; participation as interaction or

[1] We also ran the model while controlling for the regional level of GDP (we do not report these results here for reasons of space). Although there are some multicollinearity issues, as regional GDP and structural social capital are correlated, the parameters for structural social capital and the interaction effect retain their level, sign and significance. The parameter for regional GDP comes out as negative and insignificant.

participation as an instrumental action (Scaff 1975). When the latter prevails, political participation becomes a tool for achieving personal gain and may generate competition and hamper communication.

[Insert Table 5 about here]

Concerning Hypothesis 2 ("The effect of externally acquired R&D on the likelihood of introducing product and process innovation is greater for firms operating in regions associated with high levels of social capital") we detect a positive and significant interaction effect between the social interaction component of social capital and the proportion of the firm's R&D that is externally acquired in the case of product innovation, but not in the case of process innovation. Due to the non-linear nature of the logit model, the marginal effect of an interaction effect is not simply the coefficient for their interaction (Hoetker 2007; Norton et al. 2004). In addition, because there are two additive terms, each of which can be positive or negative, the interaction effect may have different signs for different values of covariates. In order to deal with this complication, we apply a procedure developed by Ai and Norton (2003) that computes correct magnitudes and standard errors of the interaction effect for each of the observations (this procedure has been implemented in Stata through the inteff module). Figures 1 and 2 provide graphical representations of the interaction effect and its significance for product innovation. Figure 1 illustrates that the strongest interaction effect occurs at medium predicted levels of probability of being innovative (approximately between 0.3 and 0.6), whereas the effect is less outspoken for low and high levels of predicted probability of being an innovator (the effect is negative in only 7 of 2464 cases). In other words, for firms with a low predicted probability of being innovators, the combination of acquiring external R&D and being located in a region with a high level of social capital makes little difference. Similarly, for firms with a high predicted probability of being innovators; they are likely to innovate regardless. Figure 2 illustrates that the interaction effect is positive and significant in the majority of cases (97.4 per cent of the observations are significant at the one-tailed five percent level). This result offers evidence of the positive role played by social capital on the firm's acquisition of external knowledge. With respect to process innovation, we find that the interaction effect is non-significant. Whereas all interaction effects are positive, they are only significant for three observations. In addition, the size effects are very small for all observations (these results are not documented for reasons of space). The interaction effects for regional political participation and R&D acquisition are never significant for both product and process innovation. In sum, we find partial support for Hypothesis 2. We find support for Hypothesis 3 ("Regional social capital increases the likelihood of firms introducing product innovation more than process innovation"), as the significance of the social interaction component of social capital is higher in explaining the likelihood of product innovation in comparison with process innovation.

[Insert Figures 1 & 2 about here]

In order to further examine Hypothesis 3, taking into account that firms may introduce product and process innovations simultaneously, we apply both multinomial logit and probit analyses as the means of estimation to assess the importance of social interactions and political participation for each of the innovation types where non-innovative firm (type A) constitutes the benchmark for the three other categories of innovation types — product (B); process (C); product and process innovative (D). The Hausman test in Appendix Table 3 indicates that we cannot reject the independence of irrelevant alternatives (IIA). Two tests are negative, which, according to Long (2006: 245), is a very common result. Hausman and McFadden (1984) note this and conclude that a negative result underlines that IIA has not been violated. The multinomial probit regressions produced almost identical results (these results are not documented for reasons of space) to those of the multinomial logit. Tables 6 reports on the results of the multinomial logit regression.

[Insert Table 6 about here]

We visualize the results of the multinomial logit analysis using odds ratio plots in Figure 3. According to Long (2006: 262), the odds ratio plots facilitate the interpretation of multinomial logit models. The odds ratio plot gives all the information also presented in Table 6. Each row represents an independent variable. The plotted letters A-D detail the categories of innovation. The bottom scale describes the estimated coefficient β*k*, *m*/*n*, where *k* is the independent variables, *n* is the base category and *m* is the category under investigation.

[Insert Figure 3 about here]

The top scale indicates the factor change coefficient exp(β*k*, *m*/*n*, δ), with δ being 1 for dummy variables *k*, and std(*xk*) for continuous variables *xk*. It gives the change in the odds of the dependent variables being *m* rather than *n* if *xk* changes by δ. In addition, the odds ratio plots communicate information about significance. A connecting line conveys that the parameter estimates are not significantly different at the ten percent level. The vertical spacing of the graph only makes the connection lines more visible. Using the plot in Figure 3, based on the multinomial logit model, we find further support for Hypothesis 3 since process innovation is affected by structural social capital (social interaction) as distinct from no innovation, and the parameter for product innovation is even higher and distinct from no innovation and process innovation. However, the results should be interpreted with caution, since the differences are only significant at the one-sided ten per cent level.

We find that the evidence is inconsistent with Hypothesis 4, since although the results show that the social interaction component of social capital is significant in explaining the likelihood of introducing product and process innovation, there is no difference between the effect of social capital on product innovation alone or the simultaneous introduction of product and process innovation. The key difference in the effect of social interaction appears to have to do with product innovation as opposed to process innovation. In general, it can also be noted that the multinomial logit regressions produce results that are consistent with the simple logit estimations.

Discussion and conclusion

This paper has illustrated that geographically bound social capital plays an important role in shaping firms' innovative capability across Italian regions. Our research has provided two sets of results. First, we found evidence that location matters: firms located in regions characterized by high level of structural social capital in terms of social interaction display a higher propensity to innovate. Second, we found support for the hypothesis that high levels of the social interaction components of regional structural social capital positively moderates the effectiveness of externally acquired R&D on product innovation. Social capital therefore, represents an important external contingency that favors the effectiveness of external R&D sourcing.

The first set of results is consistent with existing literature on the role of geographical contexts for firms' performance — e.g. industrial clusters, industrial districts, and territorial innovation systems (Brusco 1982; Lundvall 1992; Porter 1990; Romanelli and Khessina 2005; Tallman et al. 2004). Besides economic determinants for firms' innovative capability and hence competitiveness, our research has illustrated that social factors affect firms' ability to innovative as well. This finding provides empirical support to the two main arguments of scholars of social capital. First, social capital refers to the social structure of a community and therefore resides in people's relationships (Coleman 1990; Nahapiet and Ghoshal 1998; Portes 1998). Second, since it is co-owned by the parties of a relationship, it facilitates individuals' actions within the social structure (Burt 1992; Nahapiet and Ghoshal 1998). Our paper also contributes towards a better understanding of the concept of context. The term context — variously qualified and utilized, e.g. context-specific — is often "parachuted down" to explain what other explanatory variables cannot with regard to firms' performance. We usually call on context as if it were a residual variable. Our attempt to measure structural social capital in terms of social interaction — has provided empirical grounding of the social dimensions of a geographical context. Although we acknowledge that we have not fully captured all dimensions of geographically bound social capital, we submit that social interaction — as measured in our research — constitutes a first step towards a better understanding of context.

Although Napahiet and Ghoshal (1998) argue that social capital affects the conditions at the basis of the creation of new knowledge — in their words, intellectual capital, they acknowledge that social capital may also affect diffusion and exploitation of existing knowledge. In addition, Napahiet and Ghoshal (1998) and Tsai (2000) focus on social capital in intra-firm relationships providing theoretical and empirical support for the "organizational advantage" argument (Ghoshal and Moran 1996). As Napahiet and Ghoshal (1998) acknowledge, however, their analysis can be extended to other institutional settings characterized by enduring relationships, e.g. inter-organizational relationships. These two points lead to our second contribution. We have found not only that location in a region with a high level of structural social capital is conducive to firms' innovative abilities, but also that location enhances the probability of externally acquired R&D being translated into product innovations, making the "buy option" more attractive to managers. This result positions our paper within a research stream (for instance, Ahuja 2000; Baum et al. 2000; Laursen and Salter 2006; for instance, von Hippel 1987) that emphasizes that firms may gain access to knowledge and other resources they need by sharing knowledge with the current owner, provided that something is given in exchange. Existing literature on markets for innovations and technology has not examined the role of geographically bound social capital for the efficiency of introducing innovations. Our contribution within this literature is that firms' environment in terms of regional social interaction matters for firms' innovative capability. This is of course in contrast with literature that contends that the only factors that can be the basis of competitive advantage are those that cannot be traded on factor markets, and that such factors can only be accumulated internally (e.g., Dierickx and Cool 1989).

In addition, although some of the central contributions to the resource based view have been skeptical about the possibility of acquiring sustained competitive advantage based on acquired resources, this paper has supported an emerging view arguing that outsourcing of some activities (including parts of R&D) are a necessary condition for competitive advantage (Dyer and Ouchi 1993; Leiblein et al. 2002; Sobrero and Roberts 2001). In other words, the ability to outsource R&D processes may — as technologies and markets change over time — be seen as a firm-level important dynamic capability (Eisenhardt and Martin 2000). This paper has applied both social capital and transaction cost theory. Whereas there are stark differences between these perspectives in a number of respects (Foss 1993; Poppo and Zenger 1998), it is worth noting the complementarity between them in this particular case; the theoretical predictions point in the same direction, as social capital both increases the ease of interactive learning and decreases transaction costs.

The findings of the study hold implications for managerial practice. Whereas in regions with high amounts of social capital, social capital positively affects the effectiveness of externally sourced R&D and favors firm innovation; in regions with low levels of social capital, firms need to invest more in their own social capital, for instance by promoting meetings, partnerships and communication with other firms and organizations. Firms located in areas with low levels of social capital may also wish to carry out more in-house R&D, and should at least be more reluctant to outsource these complex activities. This paper has also pointed to the particularly strong organizational constraints involved in introducing process innovation: Managers should be less prone to outsource process R&D, given the embeddedness of these activities in the overall organizational procedures of the firm.

There are limitations to this study. In this paper, we have focused on the positive net effects of social capital. It should be noted, however, that social capital may have negative consequences as well, when the underlying networks have become too tight. Prominent social capital theorists, such as Coleman, have stressed the importance of dense networks as a prerequisite for the creation of social capital. However, dense networks may carry penalties, involving at least four negative effects: exclusion of outsiders, excess claims on group members, restrictions on individual freedoms, and downward leveling norms (see Portes 1998: 15 for a detailed discussion of these effects). While our measure of social capital can be considered a mixture of strong and weak ties, we share with the rest of the regional literature the inability to empirically disentangle these two sets of ties. Although an analysis that would separate these ties would be of tremendous value, not least to examine negative sides of social capital in the form of "overembeddedness" (Uzzi 1997), such an analysis is extremely difficult to do satisfactorily at a relatively high level of aggregation such as the regional level.

Another limitation of this paper is that we focus on one period only. Although we have controlled for a large number of firm- and region-specific factors and have a large sample of firms, the results of this study are based on cross-sectional data. A further limitation concerns the fact that although we have relied on two data sources, collected at the firm and regional levels, respectively, we do not know whether the externally acquired R&D was purchased in the home region. Accordingly, the positive moderation effect of the regional social interaction variable on the relationship between externally acquired R&D and innovation may have to do with the fact that a high level of regional structural social capital makes the acquiring firm better able to learn to deal with the process of outsourcing R&D, and at the same time, likely to be better connected socially to the seller firm located in the home region. Future research should collect data on the geographical origin of the acquired R&D to disentangle these two effects.

Greater emphasis on how geographically bound social capital enables and constrains managerial behavior in other parts of the organization appears to be a fertile area for future research. In this paper, we focused on the outsourcing of R&D processes — an increasingly important element in the innovation process, but regional social capital may influence the effectiveness of other external relations of the firm, including formal collaboration between firms and external parties. Another important issue for future research is to separate the effect of social capital and R&D outsourcing on innovation at the level of individual industries to explore possible industry variation. New insights from such research can help provide guidance for managers when they have to make decisions on how to work together with external parties in their environments.

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Appendix

Appendix Table 1. Results of Principal Component Analysis

Component	Eigenvalue	Percentage of variance Explained	Cumulative percent
1	6.56	59.61	59.61
2	2.44	22.18	81.79

Appendix Table 2. First-step fractional response regressions explaining external R&D acquisition

Explanatory variable	Coeff.	S.E.
Member of a commercial consortium	0.436***	(0.131)
Member of a corporate group	0.390***	(0.102)
Acquired patents	0.536**	(0.272)
Average industry-level R&D intensity	0.153***	(0.049)
Constant	-2.671***	(0.079)
No. of obs	3282	
Log likelihood	-872	
Chi-square	24***	
ML (Cox-Snell) R2:	0.01	
McFadden's pseudo R2	0.01	

Notes: One-tailed tests: † $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$. Standard deviations in parenthesis.

Appendix Table 3. Hausman test.

	Chi2	Df	P>chi2	Evidence
A	-0.499	2	1.000	for H0
B	0.652	2	0.722	for H0
C	1.464	2	0.481	for H0
D	0.655	2	0.721	for H0

Table 1. Description of the variables included in the PCA

Variable	Description
CULAS	People aged 14 upwards who have joined meetings in cultural circles and similar groups at least once a year in the 12 months before the interview per 100 people in the same area
VOLAS	People aged 14 upwards who have joined meetings in voluntary associations and similar organizations at least once a year in the 12 months before the interview per 100 people in the same area
NVOAS	People aged 14 upwards who have joined meetings in non-voluntary organizations at least once a year in the 12 months before the interview per 100 people in the same area
NUMAS	Number of voluntary organizations per 10.000 people
MONAS	People aged 14 upwards who have given money to an association at least once a year in the 12 months before the interview per 100 people in the same area
WEFRI	People aged 6 upwards meeting friends at least once a week per 100 people in the same area
SOPAR	People aged 6 upwards attending bars!, pubs!, and clubs at least once a week in the 12 months before the interview per 100 people in the same area.
SAFRI	People aged 14 upwards who are satisfied with their relationships with friends
POPART	People aged 14 upwards who have carried out unpaid work for a political party in the 12 months before the interview, per 100 people in the same area
MONPA	People aged 14 upwards who have given money to a political party at least once a year per 100 people in the same area
COMI	People aged 14 upwards who have joined a political meeting in the 12 months before the interview, per 100 people in the same area.

Table 2. Matrix of factor loadings.

	Component1: Social interaction	Component2: Political Participation
CULAS	**0.882**	0.246
VOLAS	**0.893**	0.149
NVOAS	**0.940**	0.196
NUMAS	**0.775**	0.333
MONAS	**0.877**	0.295
WEFRI	**0.814**	-0.167
SOPAR	**0.908**	-0.010
SAFRI	**0.873**	-0.083
COMIZ	-0.586	**0.729**
MONPA	-0.115	**0.897**
POPAR	-0.349	**0.866**

Table 3: Number of innovations in each category

	No product inn.	Product innovation
No process inn.	(A) 1.201	(B) 572
Process innovation	(C) 624	(D) 830

Table 5. Correlation matrix

		Mean	Std. Dev.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1	Product innovation	0.43	0.49												
2	Process innovation	0.45	0.50	0.24											
3	Social capital I — social interaction	0.44	0.75	0.10	0.02										
4	Social capital II— political participation	-0.05	0.85	0.01	-0.02	0.12									
5	External R&D acquisition ¤	0.09	0.03	0.17	0.10	0.04	-0.01								
6	Size	89.57	210.81	0.12	0.14	0.01	-0.03	0.18							
7	Age	27.43	18.69	0.03	0.07	0.09	0.01	0.01	0.12						
8	R&D intensity	0.84	2.90	0.23	0.08	0.04	-0.02	0.27	0.06	0.00					
9	Percentage of employees with a degree	5.25	7.40	0.15	0.09	-0.05	-0.03	0.25	0.09	0.00	0.23				
10	Customer Satisfaction	0.71	0.45	0.08	0.10	-0.03	-0.02	0.05	0.08	0.04	0.06	0.09			
11	Regional Human Capital	6.28	1.77	0.05	-0.03	0.46	0.22	0.03	0.00	0.08	0.05	0.01	-0.01		
12	Regional expenditure on innovation (% of regional GDP)	0.98	0.36	0.02	0.03	-0.04	-0.35	0.03	0.06	0.11	0.07	0.04	0.05	0.36	
13	Population (in millions of people)	4.91	2.67	0.02	-0.01	0.03	0.21	-0.02	-0.01	0.14	0.02	-0.02	0.05	0.32	0.39

Note: ¤ indicates a predicted variable from the first-step fractional response estimation. Correlation coefficients above |0.04| are statistically significant at the 5 percent level.

Table 6. Results of the logit regressions for product innovation and process innovation using instrumental variables (n=2464).

	Model I Product innovation Coeff.		Model I S.E.	Model II Process innovation Coeff.		Model II S.E.	Model III Product innovation Coeff.		Model III S.E.	Model IV Process innovation Coeff.		Model IV S.E.
Social capital I — social interaction	0.189	**	(0.071)	0.122	*	(0.066)	0.216	**	(0.072)	0.127	*	(0.066)
Social capital II — political participation	0.020		(0.065)	0.057		(0.061)	0.037		(0.065)	0.061		(0.061)
External R&D acquisition ¤	3.991	*	(2.019)	3.132	†	(1.890)	3.834	*	(2.058)	3.112	†	(1.894)
Social interaction × External R&D acquisition ¤							8.787	***	(2.708)	2.176		(2.340)
Size	0.001	***	(0.000)	0.003	***	(0.000)	0.001	***	(0.000)	0.003	***	(0.000)
Age	0.002		(0.002)	0.005	*	(0.002)	0.002		(0.002)	0.005	*	(0.002)
R&D intensity	0.541	**	(0.052)	0.039	*	(0.020)	0.543	***	(0.052)	0.038	*	(0.020)
% of employees with a degree	0.019	**	(0.007)	0.013	*	(0.006)	0.020	**	(0.007)	0.012	*	(0.006)
Customer Satisfaction	0.213	*	(0.099)	0.334	***	(0.093)	0.220	*	(0.099)	0.335	***	(0.093)
Supplier dominated	-0.475	***	(0.110)	-0.024		(0.106)	-0.454	***	(0.111)	-0.018		(0.106)
Scale intensive	-0.551	***	(0.141)	0.215	†	(0.133)	-0.533	***	(0.142)	0.220	*	(0.134)
Science based	-0.454	†	(0.271)	0.019		(0.235)	-0.352		(0.275)	0.041		(0.236)
Specialized suppliers	Benchmark			Benchmark			Benchmark			Benchmark		
Regional Human Capital	-0.017		(0.034)	-0.085	**	(0.033)	-0.016		(0.034)	-0.085	**	(0.033)
Regional Expenditure on innovation (% of regional GDP)	-0.170		(0.172)	0.290	†	(0.160)	-0.129		(0.173)	0.302	*	(0.161)
Population	0.011		(0.019)	-0.020		(0.018)	-0.071		(0.019)	-2.18		(0.018)
Constant	-0.462	*	(0.232)	-0.548	*	(0.220)	-0.510	*	(0.233)	-0.560	*	(0.221)
Log likelihood	-1480			-1629			-1464			-1628		
Chi-square	435	***		138	***		413	***		139	***	
Pseudo R2	0.12			0.04			0.13			0.04		

Notes: ¤ indicates a predicted variable from the first-step fractional response estimation. One-tailed tests: † $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$. Standard deviations in parenthesis.

Table 7. Results of the multinomial logit regressions using instrumental variables (n= 2464).

	Model V						Model VI					
	Product vs. no innovation		Process vs. no innovation		Process and process vs. no innovation		Product vs. no innovation		Process vs. no innovation		Process and process vs. no innovation	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Social capital I — social interaction	0.249 **	(0.102)	0.129 †	(0.087)	0.231 **	(0.091)	0.285 **	(0.104)	0.144 †	(0.089)	0.260 **	(0.092)
Social capital II — political participation	0.071	(0.090)	0.096	(0.082)	0.059	(0.083)	0.082	(0.091)	0.094	(0.082)	0.079	(0.083)
External R&D acquisition ¤	3.755 †	(2.843)	2.558	(2.740)	5.592 *	(2.564)	3.829 †	(2.899)	2.619	(2.787)	5.346 *	(2.619)
Social interaction × External R&D acquisition ¤							7.234 **	(3.745)	0.530	(3.187)	10.155 **	(3.403)
Size	0.002 **	(0.001)	0.003 ***	(0.001)	0.004 ***	(0.001)	0.002 **	(0.001)	0.003 ***	(0.001)	0.004 ***	(0.001)
Age	0.004	(0.004)	0.008 **	(0.003)	0.006 *	(0.003)	0.004	(0.004)	0.008 **	(0.003)	0.005 *	(0.003)
R&D intensity	0.731 ***	(0.075)	0.366 ***	(0.086)	0.723 ***	(0.075)	0.731 ***	(0.075)	0.366 ***	(0.086)	0.723 ***	(0.075)
% of employees with a degree	0.016 †	(0.010)	0.006	(0.010)	0.025 **	(0.009)	0.016 *	(0.010)	0.005	(0.009)	0.025 **	(0.008)
Customer Satisfaction	0.219 †	(0.135)	0.369 **	(0.126)	0.432 ***	(0.127)	0.226 *	(0.135)	0.371 **	(0.126)	0.441 ***	(0.127)
Supplier dominated	-0.477 **	(0.151)	0.144	(0.155)	-0.374 **	(0.141)	-0.461 **	(0.151)	0.140	(0.157)	-0.352 **	(0.141)
Scale intensive	-0.702 ***	(0.209)	0.379 *	(0.186)	-0.209	(0.177)	-0.686 ***	(0.209)	0.337 *	(0.186)	-0.192	(0.177)
Science based	-0.219	(0.363)	0.361	(0.368)	-0.286	(0.346)	-0.157	(0.366)	0.371	(0.371)	-0.178	(0.348)
Specialized suppliers	Benchmark		Benchmark		Benchmark		Benchmark		Benchmark		Benchmark	
Regional Human Capital	-0.053	(0.049)	-0.132 **	(0.045)	-0.079 *	(0.044)	-0.053	(0.049)	-0.132 **	(0.045)	-0.079 *	(0.044)
Regional Expenditure on innovation (% of regional GDP)	-0.321 †	(0.242)	0.233	(0.220)	0.087	(0.217)	-0.295	(0.243)	0.229	(0.222)	0.137	(0.219)
Population	0.006	(0.027)	-0.028	(0.025)	-0.007	(0.025)	.004	(0.027)	-0.027	(-0.025	-0.012	(0.025)
Constant	-0.590 *	(0.326)	-0.828 **	(0.303)	-0.933 **	(0.299)	-0.616 †	(0.327)	-0.818 **	(0.303)	-0.992 ***	(0.301)
Log likelihood	-3040						-3034					
Chi-square	532 ***						543 ***					
Pseudo R2	0.080						0.082					

Notes: ¤ indicates a predicted variable from the first-step fractional response estimation. One-tailed tests: † $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$. Standard deviations in parenthesis.

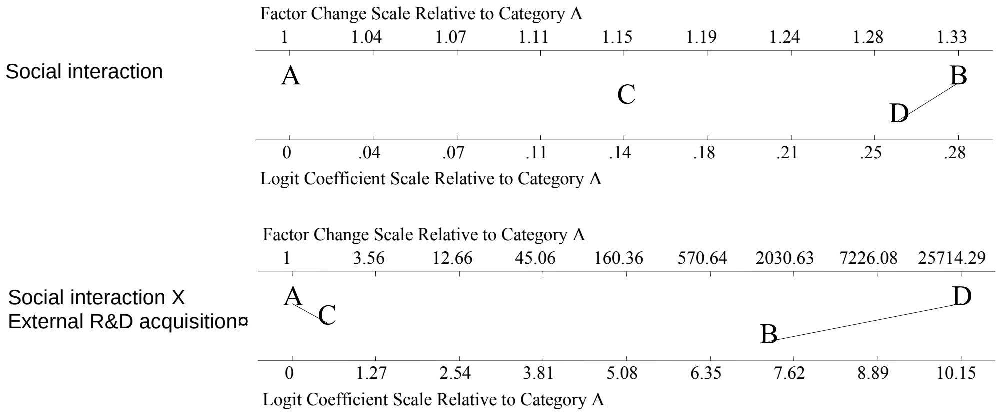

Figure 2. Odds ratio plot of the multinomial regression model

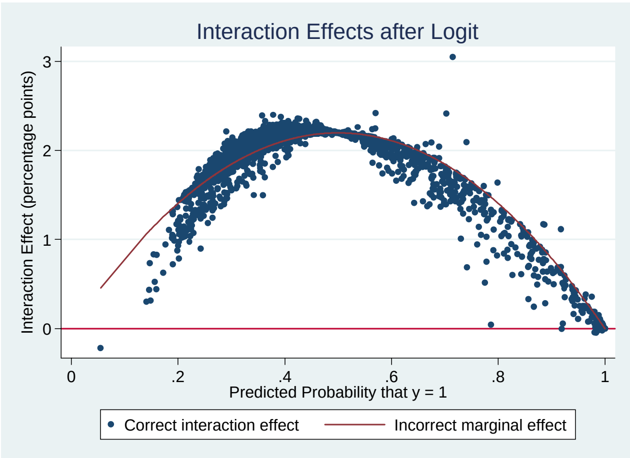

Figure 3. The size effect of the interaction between social interaction and external R&D acquisition¤

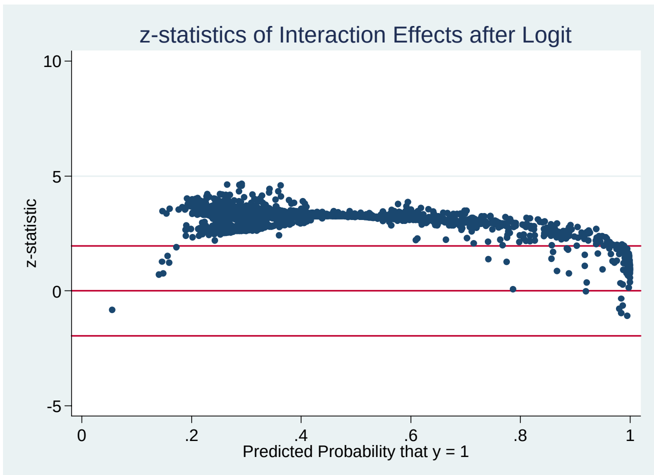

Figure 4. The significance of the interaction between social interaction and external R&D acquisition¤