Spatial and Sectoral Characteristics of Relational Capital in Innovation Activity

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Paper presented at the 41' European Regional Science Conference, held in Zagreb, 29 august - 1 september 2001

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1. Introduction

During the nineties a large interest for innovation activities has come to the fore, oriented towards the explanation of innovation activities through knowledge acquisition, as the result of spillover and external positive effects of spatial clustering. Concepts like localised knowledge, spatial competence, knowledge spillovers, knowledge externalities, localised learning processes, collective learning are put forward by a growing body of literature, with the aim to enlarge the possibility to explain innovation processes and knowledge acquisition in space.

Interestingly enough, among all the existing and growing literature, two main streams of thoughts may be envisaged. The first may be related to industrial economists, who define innovation determinants especially in knowledge acquisition, and seek to test whether the processes of knowledge acquisition are facilitated by spatial proximity and sectoral specialisation. The second stream of thoughts may be related to regional economists, who try to envisage the role of spatial effects like synergies, cooperation, collective learning, in the innovation activities developed at the local level.

The above mentioned approaches to knowledge acquisition have a common aim, that of understading whether knowledge acquisition changes according to the characteristics of the area in which it takes place, i.e. whether specialised or diversified knowledge spillovers are more effective. The reply to this question has far reaching consequences; in fact, if knowledge acquisition is facilitated by a diversified urban environment, the general statement that "since innovation becomes increasingly based on scientific and technological knowledge combined with creativity, only cities, and especially large cities, where these new resources are disproportionately concentrated will be able to compete successfully in the global economy" finds solid empirical support[1]. On the contrary, if specialised knowledge is more effective on innovation activity, the city may not be the best area where sectoral spillovers take place, and the above mentioned statement does not prove to be valid.

Although the two approaches share a common aim, their nature is rather different, as we will stress in the first part of the paper. The approach of industrial economists is based on knowledge acquisition in space, where space is meant to be a physical space, measured in terms of physical distance. Regional economists analyse knowledge exchange in space, meant not only as a physical space, but as a "relational space", intended as physical proximity characterised by cultural and

[1] Much work has been developed on the idea that cities are the major "islands" of innovation. See, on this subject, the recent work by Simmie, 1998 and 2001, Simmie and Hart, 1999, Simmie and Sennet, 1999.

social proximity. In this approach, what really matters to facilitate knowledge acquisition is not the stock of knowledge present in a certain environment, which spills over, but the flows of knowledge which take place thanks to intense cooperation among local actors (lasting over time) with a highly specialised and locally mobile human capital, with spin-off mechanisms from local firms. These channels of knowledge acquisition are more typical of a specialised local area, of what has been defined in the literature, a milieu innovateur[2]. According to the theory, knowledge acquisition via these channels is made possible by geographical proximity and, moreover, by relational proximity, the latter being defined as cooperation and synergy that happen thanks to economic integration of firms, socio-cultural homogeneity of local population and dense public and private partnership. The presence of synergy and cooperation among local actors and within the local labour market, which lead to knowledge exchange is what we call relational capital. The presence of relational capital in an area may even explain the sources of strategic knowledge for specialised areas, useful to compete in a regime of globalisation.

This paper provides an insight into this debate, by highliting the concept of relational capital, and its role in innovation processes. Moreover, the aim of the paper is to test the degree to which relational capital has a role in the innovation activity, and under which sectoral and spatial conditions this relationship is more robust. In this research note, we focus on three possible dimensions which may provide an insight into this issue: the size of firms, from one side, and spatial and sectoral characteristics of the area, from the other. By spatial characteristics of local areas, the nature of the area is intended, i.e urban areas, local districts or non-urban areas; by sectoral characteristics, the degree of sectoral specialisation is intended, i.e. sectorally specialised vs. diversified local areas. It is in fact reasonable to expect that small firms in specialised areas take advantage of scientific knowledge spillovers or of relational capital in a rather different way than large firms located in urban areas do. By the same token, it is reasonably to expect different behaviours among firms of the same size located in different geographical contexts, or among firms of a different size located in the same geographical context. In order to find out the role of firms' size and of sectoral and spatial conditions, a knowledge production function at the firm level is tested on a database of 133 firms of different size located in different geographical contexts.

The paper is structured as follows. A description of similarities and differences between the two approaches to knowledge production, together with a more in depth description of the concept of relational capital, is presented in Sec. 2, and the estimated model in Sec. 3. Sec. 4 presents the data and variable on which the empirical analysis is carried out. The main results are presented in Sec. 5, while Sec. 6 contains some concluding remarks.

2. Relational Capital in Knowledge Production

Most of the literature on innovation developed in the last decade by industrial economists takes into consideration the processes of knowledge production and acquisition, strengthening the fact that spatial proximity facilitates learning processes through mechanisms of knowledge spillovers: knowledge, and especially sticky knowledge, as Von Hipple (1994) defined highly contextual and uncertain knowledge, is best transmitted via face-to-face interactions and frequent contacts, and thus it takes advantage of geographical proximity. For this reason the presence of a high number of firms of the same sector located in a limited geographical area can facilitate knowledge acquisition, since sticky knowledge can easily spill over and be applied to similar productions. In this sense, the definition of knowledge spillovers provided by Griliches (1992) is extremely appropriate:

[2] For the "milieu innovateur" theory, see Aydalot, 1986; Aydalot and Keeble, 1988; Camagni, 1991b; Maillat et al., 1993; Ratti et al., 1997; RERU, 1999.

"knowledge spillover means working on similar things and hence benefiting much from each others' research" (Feldman and Audretch, 1999).

The debate in this growing body of literature develops around two research issues (Table 1): the first issue deals with the question whether knowledge spillovers are more intense in intra-industry or inter-industry exchange of knowledge. The different empirical analyses have not yet found a common result, but it seems that most results are in favour of the diversity thesis. The second issue is the spatial range of knowledge spillovers, which has been estimated to be 50 miles from the innovating MSA for university research (Anselin et al., 1997).

Table 1. Different Approaches to Knowledge Production

Approaches *Elements*	*The industrial dynamic approach*	*The spatial-relational approach*
Key research issues	Intra vs. inter-industry knowledge spillovers Spatial range of knowledge spillover	Importance of relational capital in innovation activity Presence of relational capital in areas of different nature and different degrees of specialisation Relational capital vs. dynamic urbanisation economies in area of different nature and different degrees of specialisation
Concept of space	Physical	Relational
Kind of approach	Mostly empirical	At present mostly conceptual
Main references	Griliches, 1992 Ellison and Glaeser, 1999 Glaeser, 1997 Glaeser et al., 1992 Porter, 1990 Von Hipple, 1994 Jaffe, 1989 Jaffe et al., 1993 Feldamn, 1994 Audretsch and Feldman, 1996 Feldman and Audretsch, 1999 Oerlemans, Meeus and Boekema, 1998 Satterthwaite, 1992 Beeson, 1992	Camagni, 1991 Camagni, 1999 Camagni and Crevoisier, 2000

Within the literature on knowledge spillovers, an important role is played by university spillovers: universities are one channel for knowledge production, which easily becomes a knowledge externality for firms which receive at low marginal costs technological and scientific information via both publications and trained manpower exposed to the scientific undertakings of researches: universities generate technological externalities which firms abosorb and translate into economic value (Antonelli, 1999; Jaffe, 1989; Anselin et al., 2000).

As already mentioned in the introductory chapter, the second body of literature dealing with innovation in space is more of a spatial nature. The main characteristic of this literature is that it emphasises all synergies and cooperation which take place in limited geographical areas as determinants of knowledge production in the form of innovation output. The kind of learning mechanisms envisaged in this theory which enhance innovative creativity is a *collective learning*. By the term *collective* a learning in meant which takes place in *a socialised way*, thanks to a creative knowledge which cumulates outside the single firm and at the same time within the local area, as a sort of club good: no (or low) rivalry in its use by agents belonging to the club; very limited excludability of external agents from taking advantage of it. In this sense, collective learning supplies typical "club goods" à la Buchanan (1965) from which club externalities may be exploited. In this case, the "club" is represented by the economic agents located in the area.

Collective learning is the territorial counterpart of learning processes happening inside the firm; it is thought as the vehicle for knowledge transmission, both in a temporal and in a spatial dimension. In the former dimension, the transfer of knowledge is guaranteed by an element of continuity; in the latter by the interaction among agents (Capello, 1999a and 1999b). Collective learning may thus be defined as a dynamic and cumulative process of knowledge production, transfer and appropriation, taking place thanks to the interactive mechanisms which are typical of an area where a strong sense of belonging, and strong relational synergies take place. The channels through which collective learning takes place are in fact thought to be (Camagni, 1995; Capello, 1999b):

- *a high mobility of specialised labour within the area and a low mobility outside the area*; this structure of the local labour market guarantees cross-fertilisation processes for firms and professional upgrading for individuals; a local know-how grows through a collective and socialised process, subject, and this is the other side of the coin, to risks of isolation and locking-in, unless external energy is also captured through selected external co-operation linkages;
- *stable linkages between suppliers and customers*: stable input-output relationships generate a codified and tacit transfer of knowledge between suppliers and customers, which cumulates over time and defines patterns of incremental innovation which feed a specific technological trajectory;
- *intense innovative interactions with suppliers and customers and mechanisms of local spin-off*. Local milieux provide both the social and the market preconditions for this phenomenon to take place: from the social point of view, high trust and common sense of belonging to the same cultural society make this process acceptable[3].

Two main elements characterise the channels through which collective learning takes place (Camagni, 1995):

- geographical proximity, and
- what is called "relational proximity" or "relational capital", encompassing the linkages that happen thanks to economic integration of firms, socio-cultural homogeneity of local population and dense public\private co-operation and partnership[4].

While the former is stressed also by industrial economists, the latter, on the contrary, is typical of the spatial approach. Relational capital, or better territorial relational capital, since it stems from territorial relationships, resides in different elements:

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[3] On the social homogeneity of local districts a vast literature exists. See among others, Bagnasco and Trigilia, 1984; Becattini, 1979 and 1990. For an overall synthesis of local district theories, see Rabellotti, 1997; Bramanti and Maggioni, 1997; Pietrobelli, 1998.

[4] The idea that territorial proximity is insufficient for milieu mechanisms has already been put forward by the French school on "proximity". See, among others, Bellet et al., 1993; Dupuy and Gilly, 1995; Rallet, 1993; Gilly and Torre, 2000.

- the synergy and cooperation element, embedded in implicit or explicit cooperation among actors, based on trust[5], sense of belonging to a comunity sharing the same values (Aydalot, 1985; Maillat et al., 1993), what Storper (1995) calls "untraded interdependences";
- the socialised nature of the production of specific resources, like skilled labour force, human capital for high-level managerial functions, marketing, information transcoding (Gordon, 1993; Camani, 1991).

The existence of relational capital in an area supports knowledge production in two ways:

- a direct way, by increasing the flows of knowledge, especially of tacit knowledge in the words of Antonelli (1999) or sticky knowledge in the words of von Hipple (1994);
- an indirect way, by decreasing uncertainty which characterises the production of both tacit and codified knowledge, through socialised management and transcoding of information, and ex-ante coordination and control over competitors' choices.

Thus, by defintion, relational capital is expected to be present in specialised areas, where sectoral homogeneity leads to high local interactions between suppliers and customers, or among local economic agents in general, and to a highly specialised local labour market. It has even be underlined that since cooperation and synergy are the major way throuh which knowledge is acquired in specialised areas, these latter run the risk of atrophy and lock-in their knowledge trajectory. In order to overcome such a risk, external networking, in the form of strategic alliances, non-equity agreements, technological cooperation, are necessary: they allow local firms to capture some of the necessary assets from outside, overcoming the costs of pure internal knowledge development. This model is in a sense intermediate between internal and collective learning, in that it opens the firm to the general context, but maintains it into a set of selected and targeted relationships (Camagni, 1991).

A different situation characterises urban areas; while geographical proximity is a genetic element of an urban environment, relational capital, in the forms of synergy, vertical and horizontal cooperation among local firms, social production of human capital, is in reality not present by definition in the city. Two different archetypes of cities have recently been defined (Camagni, 1999), according to the degree to which relational capital is present, and influences innovative capacity of the city:

- the *city as a milieu*, where the relational proximity gives rise to an urban context organised as a milieu, i.e. a territory characterised by a set of social and economic relations localised in a limited geographical space, where knowledge production takes place through territorial relational capital;
- the *urban production milieu*, i.e. a network of informal or selected linkages developed around a common specialisation sector or "filière", developing inside the urban context, and working on the basis of collective learning mechanisms and common sectoral identity. If this is the case, also firms located in urban areas and operating in specialised sectors acquire knowledge through relational capital, while for non specialised sectors traditional channels of urban knowledge production, i.e. the presence of scientific urban institutions (universities, large public and private research centres) may be the sources of innovation and growth.

The opposite archetype to the above mentioned ones is that of the "pure city". In this case, the main characteristics of a city emerge; an area of strong sectoral despecialisation, with important physical agglomeration economies (like the presence of advanced infrastructure) with private services for

[5] The role of social capital, and in particular of trust and civic cooperation, on economic performance is regarded as a crucial issue for economists. On this issue see Knack and Keefer, 1997.

different markets, social heterogeneity of cultures. In the pure city, learning mechanisms for firms stem from the presence of the so called “creativity centres”, i.e. of universities, large private and public research centres, which represent the traditional channels of knowledge production in an urban area. The latter knowledge production channels can be labelled dynamic urbanisation economies: they take in fact the form of externalities that firms receive from being located in an urban environment, whose intensity very much depends on urban size. Their dynamic nature differenciates them from the traditional (static) locational (urbanisation vs. localisation economies) advantages of the sixties[6], which were used to explain static efficiency of urban areas, rather than dynamic efficiency. Dynamic urbanisation economies, defined as knowledge production through traditional urban channels like universities and research centres, are very similar to “scientific knowledge spillovers”, quoted by industrial economists.

The spatial-relational approach presented above has the characteristics of being of a conceptual nature, being validated so far only by a qualitative empirical analysis. In the line of previous research works of the author[7], this paper has the general aim to present quantitative empirical support to the hypothesis that relational capital plays a role in knowledge production.

A comparison with the industrial economists’ approach is interesting once again. In their approach, industrial economists are able to test the sources for knowledge acquisition through econometric analyses. In general, the estimated econometric models test the explicative power of sectoral specialisation and diversity indices on the stock of knowledge, measured in terms of numbers of new products introduction, or number of patents awarded (Feldman and Audretch, 1999). Interestingly enough, in all the literature on knowledge spillovers the variables used to explain the innovation activity (measured in terms of either patents or as a number of technological innovations that resulted in new products) are indicated as either private and academic R&D expenditures or employment, with the addition of variables capturing agglomeration and size effects, like the degree of specialisation in the area, the level of business services and the share of large firms (Anselin et al., 2000). The typical characteristic of the above mentioned empirical analyses is that the innovation output is measured through indices of stock of knowledge inputs (private and academic R&D) (Table 2).

Our empirical analyses presents methodological differences with the previous body of literature which in some sense stem from the different conceptual approach. Our interest lies in the relationship between the presence of relational capital and knowledge production, which changes drastically according to the sectoral differences of the area (specialised vs. diversified areas), the nature of the local areas (urban vs. local districts areas), and the size of firms (SMEs vs. large firms). Having these issues in mind, our methodology is based on the estimate of a knowledge production function at the firm level; innovation output, measured in terms of the number of product innovations developed by firms, is regressed on proxies for relational capital, i.e. for synergies and cooperation which stem from territorial relationships (Table 2).

The main difference with the industrial approach is that the nature of the area in which knowledge production takes place plays a major role in our approach. While all empirical analyses developed by industrial economists are developed in urban areas, in our approach the nature of the area (local distrct vs. urban areas) is rather important to understand knowledge spillovers.

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[6] See, among others, Hoover, 1937; Hirsch; Alonso, 1971; Mera, 1973; Henderson, 1974, 1985 and 1996; Segal, 1976; Shefer, 1973; Sveiskauskas, 1975; Carlino, 1980; Mills, 1970 and 1993; Sveikauskas et al., 1988.

[7] See Capello, 1999 and 2001.

In our approach, it becomes interesting to test whether firms located in different areas take advantage of relational capital in their innovation activity and whether firms appreciate more scientific knowledge spillovers or relational capital in their innovation activity.

Table 2. Different Empirical Approaches to Knowledge Production

Approaches *Characteristics*	*The industrial (dynamic) approach*	*The spatial-relational approach (the methodology used in this paper)*
Dependent variable	Firms innovation (number of patents or number of innovations achieved in each sector)	Firms innovation (number of innovations achieved or probability of innovation)
Independent variables	Knowledge Inputs (private and academic R&D expenditures or employment)	Relational Capital (cooperation and synergies among local actors) Scientific Knowledge Spillovers (presence of private and public research centres in the area)
Level of analysis	Sectoral level	Firm level
Space	Homogeneous	Heterogenous
Methodology used	Multiple regression analyses at sectoral level	Multiple regression analyses or binomial logit analyses at the firm level

3. The Model

In order to reply to our research questions, a model has been structured, based on a knowledge production function à la Griliches (1979). In essence, this is a two factor production function at the firm level where K is a proxy for knowledge, RC is a proxy for relational capital and SKS a proxy for scientific knowledge spillovers. Moreover, a series of interaction elements, measuring the effects of relational capital and scientific knowledge spillovers on firms size and sectoral characteristics of the area, characterises our knowledge production function, which reads as follows:

$$K = \alpha + \beta SKS + \gamma(\ln S * SKS) + \eta(\ln LQ * SKS) \quad (1)$$

for what concerns scientific knowledge spillovers, and

$$K = \chi + \phi RC + \delta(\ln S * RC) + \varepsilon(\ln LQ * RC) \quad (2)$$

when relational capital is taken into consideration. In addition to these variables, a vector indicanting firms' size is included when the degrees of freedom allow to test a wider model. We were unable to run a single model containing both the relational capital and the scientific knowledge spillovers variables because of the low numbers of degrees of freedom. Our aims could however be achieved by estimating the equations separately.

The functional form chosen easily leads to the measurement of the effects that scientific knowledge spillovers have on the innovative capacity of the firm, by calculating the first derivative of equation (1) with respect to scientific knowledge spillovers:

(3)

and calculate the way in which it varies according to different values of firms size or location quotient.

Instead, if the interest is to measure the degree to which relational capital plays a role in the innovation activity of the firms, it is possible by calculating the first derivative of equation (2) with respect to relational capital as follows:

$$\frac{\delta K}{\delta RC} = \beta + \phi \ln S + \mu \ln LQ \qquad (4)$$

and calculate it for the different levels of firms size and sectoral specialisation of the area.

The estimate of such a model allows us to explore the following issues related to relational capital and knowledge production:

a) the relationship between relational capital and innovation activity, as a proxy for knowledge acquisition, and the spatial and sectoral contexts in which this relationship takes place the most (urban vs. non-urban; specialised vs. non speciased sectors of the area);
b) the relationship between scientific knowledge spillovers and innovation activity, as a proxy for knowledge acquisition, and the spatial and sectoral contexts in which this relationship takes place the most (urban vs. non-urban; specialised vs. non speciased sectors of the area);
c) the importance of relational capital (typical of specialised areas) vs. dynamic urbanisation economies (typical of urban environments) for the innovative activities of firms located in an urban environment;
d) the role played by firms size in appreciating knowledge externalities. It is in fact a general impression that large and small firms tend to take advantage of territorial relational capital in a different way.

4. Data and Variable Definition

The above mentioned model is estimated at the firm level. This means that the observations we have represent the behaviour of single firms. In particular, we have collected a number of information regarding innovation activity, territorial relationships of the firm, importance of these territorial relationships for the innovation activity of the firm, firms size (employment and turnover), and sector in which firms operate. This information has been collected via a direct questionnaire to 133 firms, randomly chosen among a number of sectors and of geographical areas within two Italian regions, namely Liguria and Emilia-Romagna.

The sample of firms has been ex-post divided beween urban and non-urban areas, on the basis of the location of the firms in cities, namely Genova, La Spezia and Savona, in Liguria, and Bologna and Reggio Emilia, in Emilia-Romagna (Table 3).

Table 3. Geographical Areas Analysed

Regions	*Urban Areas*	*Non-urban Areas*	*Local Districts (selected within non-urban areas)*
Liguria	Genova Savona La Spezia	Sarzana (La Spezia) Albisola (Savona) Millesimo (Savona) Albenga (Savona) Cogoleto (Savona) Monconesi (Genova) Chiavari (Genova) Cicagna (Genova) Lerici (La Spezia) Serra Riccò (Genova) Carcare (Savona) Busalla (Genova) Ronco Scrivia (Genova) Vezzano (La Spezia) Cairo Montenotte (La Spezia) Santo Stefano di Magra (La Spezia) Vezzano (La Spezia) Cairo Montenotte (La Spezia) Santo Stefano di Magra (La Spezia) Arcola (La Spezia) Carasco (Genova) Ortonovo (La Spezia) Follo (La Spezia) Vado Ligure (Savona) Dego (Savona) Bolano (La Spezia) Ceranesi (Genova) Quiliano (Savona) Altare (Savona) Cosseria (Savona)	Vezzano (La Spezia) Cairo Montenotte (La Spezia) Santo Stefano di Magra (La Spezia) Arcola (La Spezia) Carasco (Genova) Ortonovo (La Spezia) Follo (La Spezia) Vado Ligure (Savona) Dego (Savona) Bolano (La Spezia) Ceranesi (Genova) Quiliano (Savona) Altare (Savona) Cosseria (Savona)
Emilia Romagna	Bologna Reggio Emilia	Ferrara (Ferrara) Ravenna (Ravenna) Serramazzoni (Modena) Copparo (Ferrara) Mirandola (Modena) Modena (Modena) Rimini (Rimini) Concordia sulla Secchia (Modena) Luzzara (Reggio Emilia) Carpi (Modena) Scandiano (Reggio Emilia) Correggio (Reggio Emilia) Rio Saliceto (Reggio Emilia) Castello d'Argile (Bologna) Forlì (Forlì) Rubiera (Reggio Emilia) Albinea (Reggio Emilia) Coriano (Rimini)	Luzzara (Reggio Emilia) Carpi (Modena) Scandiano (Reggio Emilia) Correggio (Reggio Emilia) Rio Saliceto (Reggio Emilia) Castello d'Argile (Bologna) Forlì (Forlì) Rubiera (Reggio Emilia) Albinea (Reggio Emilia) Coriano (Rimini)

Into brackets: administrative provinces to which local areas belong

Moreover, within non-urban areas, a group of local districts has been envisaged, chosen on the simultaneous presence of a high concentration of small firms in the sector and a high sectoral specialisation in the sector in which the firm operates (Table 3).

The variables chosen for the estimate for the model are presented in Table 4. Typically, knowledge is measured as innovation, or number of patents, divided by the number of employees. We decided to use the number of product innovation developed by the firms and in particularly the number of product innovation developed by the firm, multiplied by a weight reflecting the quality of the innovation achieved. In particular, we attributed a weight of 0.5 for a change in the existing product, a weight of 1 for a new product within the same series, a weight of 1.5 for significant and radical changes in the product developed by the firm. The assessment of the innovation quality was provided by the firms themselves during the interview.

Table 4. Variables Specification

Variables	*Proxies*
Knowledge	- Number of product innovation multiplied by a weight representing product innovation quality on the number of employees
Firm Size	- Turnover (million lire)
Sectoral Specialisation	- Number of employees in each sector on total number of employees in the area / Number of employees in each sector on total number of employees in the region
Small Firm Concentration	- Number of employees in small firms (<19) in each sector on total number of employees in the sector in the area/ Number of employees in small firms in each sector on total number of employees in the sector in the region
Channels for knowledge acquisition	
- Scientific knowledge spillovers	- Importance of proximity to public and private research centres for the innovation activity of the firm (factor 2 of factor analysis A)
- Relational capital	- Knowledge acquired from other local firms via the local labour market (more than 50% of employees recruited by other local firms and trained in other local firms) (factor 1 of factor analysis B).
- External networking	- High share (>50%) of cooperative firms located outside the area whose collaboration allows a control on strategic complementary assets of local firms (factor 1 of factor analysis C).

Firms’ size is easily measured with the turnover of the firm, or the number of employees. We decided to use the turnover, although also the number of employees is also available.

Sectoral specialisation is a location quotient calculated as the share of employees in the sector in the area, compared with the same share at the regional level. The concentration index is calculated as the share of small firms’ employees on total employees of a particular sector and compared with the same share at the regional level. The source of sectoral employment data for both the sectoral and concentration indices is the 1996 Industry Census, for the NUTS3 geographical level, at two digit sectoral level.

Thanks to the information obtained via the questionnaire, we were able to build indices for the two different channels of knowledge acquisition, namely relational capital and scientific knowledge spillover. In order to build these indices, we run factor analyses on the different groups of questions with the achievement of two advantages: a) a reduction of the variables present in the questionnaire; b) a transformation of discrete data into continous variables[8]. The results of the factor analysis are presented in Table 1 of the Appendix.

For what concerns scientific knowledge spillovers, the factor measuring the importance of proximity to public and private research centres for the innovation activity of the firm is a good proxy. For what concerns relational capital, the factor capturing knowledge acquired by other local firms via the labour market is a good indicator for the importance of the local labour market as a vehicle of knowledge. In fact the factor merges the results of two questions, one dealing with a high share of employees previously working in other local firms, and one related with the presence of a high share of employees previously trained in other firms. Finally, we were also able to build a proxy for external networking, i.e. a strong cooperation with external firms for the control on strategic complementary assets. This variable is useful to estimate whether it is true that external knowledge may be a good channel for long term survival of local milieux, which otherwise risk atrophy and decline for the decreasing marginal rates of their local knowledge production.

Table 5 presents the characteristics of the variables by geographical areas. Firms are both small and large firms; the number of employees presents a range from 1 to 240 employees, and turnover from 300 to 138000 million lire. We have firms operating in non specialised sectors (0.001 is the minimum location quotient) to firms operating in highly specialised sectors (8.45 is the maximum location quotient). Nearly the same range characterises the concentration index, which goes from 0.001 to 11.2. As expected, local districts are characterised by small firms (maximum employment level is equal to 81) and very high specialisation and concentration indices (location quotient > 1). Urban areas are characterised by rather small firms, and the sectoral specialisation and the concentration index are quite low. Non-urban areas are in reality characterised by a mixture of firms (from very small to very large) and by a mixture of spatial characteristics (from very low to very high specialisation and concentration indices).

Independence among these variables is witnessed by the correlation matrix (Table 6) which represents a good starting point for the estimate of our models.

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[8] Factor analysis is in fact a statistical technique used to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables. The basic assumption of factor analysis is that underlying dimensions, or factors, can be used to explain complex phenomena. The goal of factor analysis is thus to identify the not-directly-observable factors based on a set of observable variables, reducing their number without losing too much of their explanatory power.

Table 5. Variables Characteristics by Geographical Areas

	Total	*Urban Areas*	*Non-urban Areas*	*Local Districts (selected within non-urban areas)*
Regions				
- Liguria	88	39	49	28
- Emilia Romagna	45	4	41	15
Sample	133	43	90	43
Turnover (million lire)				
- Min	300	400	300	500
- Max	138.000	23.150	460.000	29.000
- Mean	6.850	5.175	5437	9808
- Standard deviation	13.729	5133	7.444	21.487
Employment (number)				
- min	1	1	1	4
- max	240	84	240	81
- mean	26	20	29	37
- standard deviation	32	18	37	48
Sectoral Specialisation Index (location quotient)				
- min	0.001	0.16	0.001	1.03
- max	8.45	1.56	8.45	8.45
- mean	1.61	1.04	1.88	3.22
- standard deviation	1.87	0.35	2.21	2.56
Small Firm Concentration Index (location quotient)				
- min	0.001	0.27	0.001	1.03
- max	11.25	1.31	11.25	11.25
- mean	1.86	1.00	2.26	4.04
- standard deviation	2.16	0.22	2.52	2.65

Table 6. Correlation Matrix
(Pearson Correlation Coefficient)

	Turnover (ln)	Sectoral specialisation (ln)	Scientific knowledge spillover	Relational capital	External networking	Product innovation
Turnover (ln)	1	0.05	-0.08	0.00	-0.08	-0.13
Sectoral specialisation (ln)		1	0.05	0.091	-0.093	-0.21
Scientific knowledge spillover			1	0.007	0.05	0.17
Relational capital				1	0.10	0.007
External networking					1	-0.061
Product Innovation						1

5. The Empirical Analysis

5.1 The Results

We report the final results of the estimates of equations (1) and (2) for the different geographical areas in Table 7a and 7b. We encountered some limitations caused by the low degrees of reedom for what concerns the models regarding urban areas and local districts, which present a lower number of observations. In the case of these two geographical areas, we estimated equations (1) and (2), reducing the independent variables to the lowest possible numbers. For the wider sample, concerning non-urban areas, some models have been estimated, including the size of firms as an explicative variable. Moreover, as fas as the local districts are concerned, the variable for external networking had no explicative power on the level of innovation, and we had therefore to drop it.

Table 7a. Regression Results for Non Urban Areas

Variables	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Constant	0.002 (2.51)	0.004 (3.06)	0.02 (2.39)	0.003 (3.22)	0.016 (5.03)	0.005 (3.58)
Firm Size (ln)			-0.09 (-3.83)		-0.004 (-4.18)	
Scientific knowledge spillovers				0.046 (2.40)	0.04 (2.24)	0.04 (2.37)
Relational capital	-0.11 (-4.44)	-0.11 (-4.50)	-0.09 (-3.83)			
Relational capital * Firm Size (ln)	0.008 (2.78)	0.08 (2.93)	0.006 (2.11)			
Relational capital * specialisation index (ln)	0.008 (2.88)	0.008 (2.75)	0.008 (3.0)			
Scientific knowledge spillover * Firm Size (ln)				-0.003 (-1.50)	-0.002 (-1.16)	-0.002 (-1.4)
Scientific knowledge spillover * specialisation index (ln)				-0.003 (-1.62)	-0.004 (-1.8)	-0.003 (-1.7)
Local District Dummy		-0.003 (-1.78)				
R-square	0.21	0.24	0.25	0.07	0.23	0.10
Durbin Watson Statistic	1.88	1.91	1.8	2.0	1.78	2.04
Test- F	7.54	6.66	6.97	0.10	6.36	2.43
Number of observations	89	89	89	90	90	90

Dependent variable: Weighted number of product innovations per employee

Table 7b. Regression results for Urban Areas and Local Districts

Variables	*Model 1 Urban Areas*	*Model 2 Urban Areas*	*Model 3 Local Districts*
Constant	0.005 (3.60)	0.003 (2.44)	0.001 (5.78)
Scientific knowledge spillovers		0.013 (2.35)	
Relational capital	0.022 (-2.53)		-0.009 (-2.67)
Relational capital * Firm Size (ln)	-0.007 (-2.37)		0.0009 (2.20)
Relational capital * specialisation index (ln)	0.016 (2.22)		0.001 (2.06)
Scientific knowledge spillover * Firm Size (ln)		0.007 (2.71)	
Scientific knowledge spillover * specialisation index (ln)		-0.01 (-2.68)	
R-square	0.22	0.24	0.21
Durbin Watson Statistic	2.18	2.3	1.75
Test- F	7.54	8.53	3.7
Number of observations	43	43	43

Dependent variable: Weighted number of product innovations per employee

The importance of the estimates of the models is that one can calculate the effects of different knowledge acquisition channels on product innovation, and measure how this effect changes according to the firms size and sectoral specialisation in which firms operate. As expected, the effects that relational capital (or scientific knowledge spillovers) has on firms' innovation capacity changes drastically, according to the size of the firm, the sectoral specialisation and the spatial characteristics in which firms operate.

a) Non Urban Areas

In non-urban areas, large firms are the ones which exploit the positive effects of relational capital on innovation the most (Fig. 1a); this result suggests that a critical size is necessary in order to achieve advantages from the local labour market. As expected, a condition which facilitates the exploitation of the positive advantages on innovation associated with relational capital is a high sectoral specialisation. This is confirmed by the estimated model 2 of Table 6a, where a negative effect of relational capital on innovation is associated with a negative sign of the local distrct dummy variable: if it is true that relational capital does not play a role on the innovative activity of firms, this is even more true in non-specialised local areas (Fig. 1b). The two results analysed together lead to the conclusions that relational capital has a positive influence on knowledge production in specialised non-urban areas organised around a large firm.

The opposite situation characterises the effects of scientific knowledge spillovers on innovation activity (Fig. 2). They are more appreciated by small firms and in firms operating in highly specialised sectors. This unexpected result may be explain by the fact that public and private research centres in non-urban areas undertake research in the most specialised sectors of the area, and for this reason they may turn out to be a channel for specialised knowledge acquisition, rather than diversified knowledge, as in the case of urban areas.

Figure 1. The Effects of Relational Capital on Innovation Activity of Firms In Non-Urban Areas

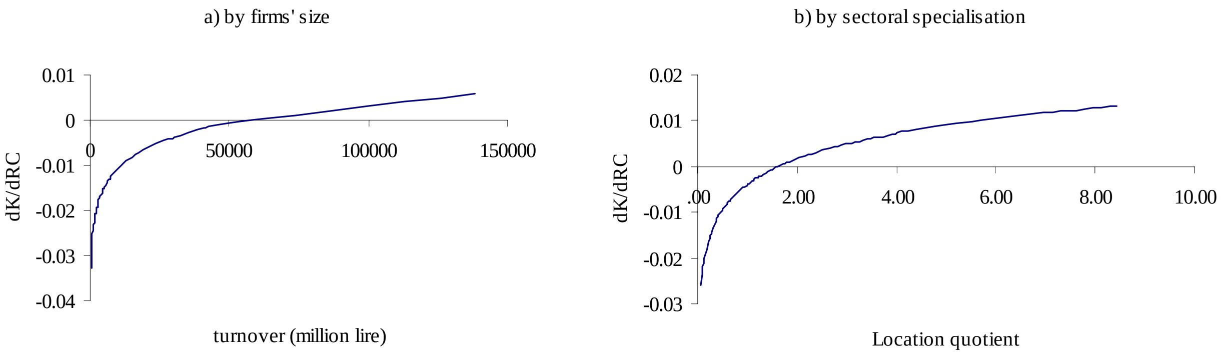
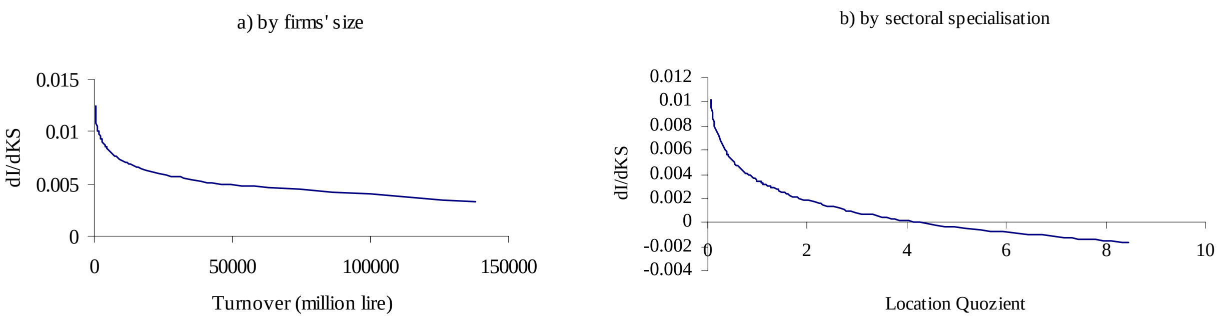


Figure 2. The Effects of Scientific Knowledge Spillovers on Innovation Activity of Firms In Non-Urban Areas



b) Urban Areas

In the case of urban areas, the results are particularly interesting. Figure 3 shows the effects of relational capital on the innovation capacity of firms, for different firms size (Fig. 3a) and different levels of sectoral specialisation in which firms operate (Fig. 3b). In urban areas, relational capital plays a positive (though decreasing) effect on product innovation only for small firms; moreover, interestingly enough, the positive effects of relational capital on innovation activity play a role especially in those firms operating in specialised sectors of the urban area. A result like this witnesses the existence of urban production milieu effects, i.e. the presence of specialised filières within the urban area where mechanisms of synergy and cooperation, traditionally linked to SMEs areas, take place among small firms and have an important role on the innovation activity of the area.

The results obtained on the effects of relational capital on innovation activity are reinforced by those obtained by taking into consideration scientific knowledge spillovers, shown in Figure 4. The effects of scientific knowledge spillovers on innovation increases with firms' size, and decreases for higher levels of sectoral specialisation. Scientific knowledge spillovers seem thus to be appreciated more by large firms in non-specialised sectors, being a typical urban externality. Interstingly enough, these results confirm a previous study developed by the author on a different database on five metropolitan areas in Europe, namely Amsterdam, London, Milan, Paris and Stuttgart (Capello, 2001).

Figure 3. The Effects of Relational Capital on Innovation Activity of Firms in Urban Areas

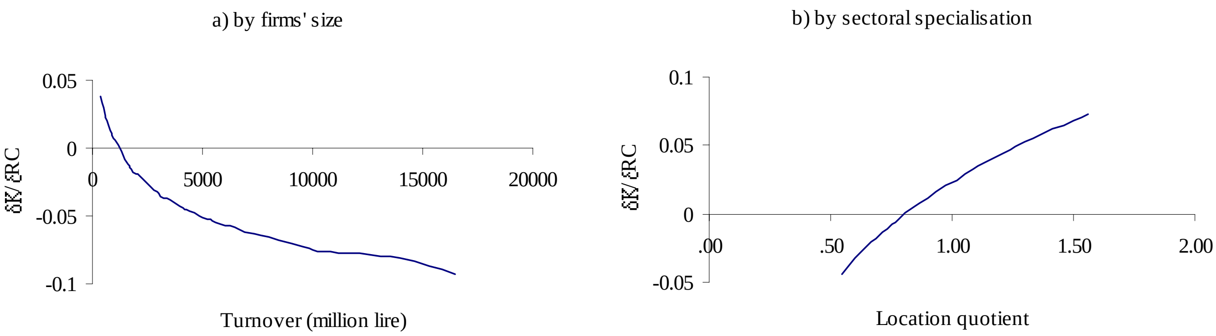
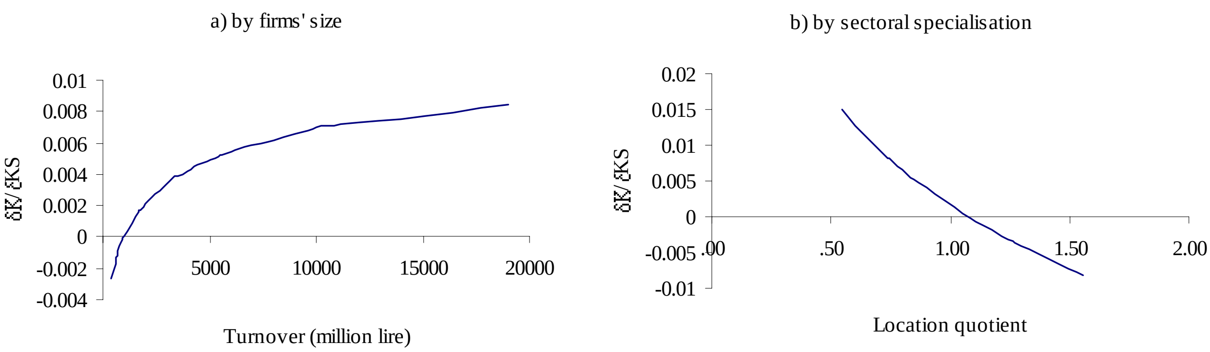


Figure 4. The Effects of Scientific Knowledge Spillovers on Innovation Activity of Firms In Urban Areas

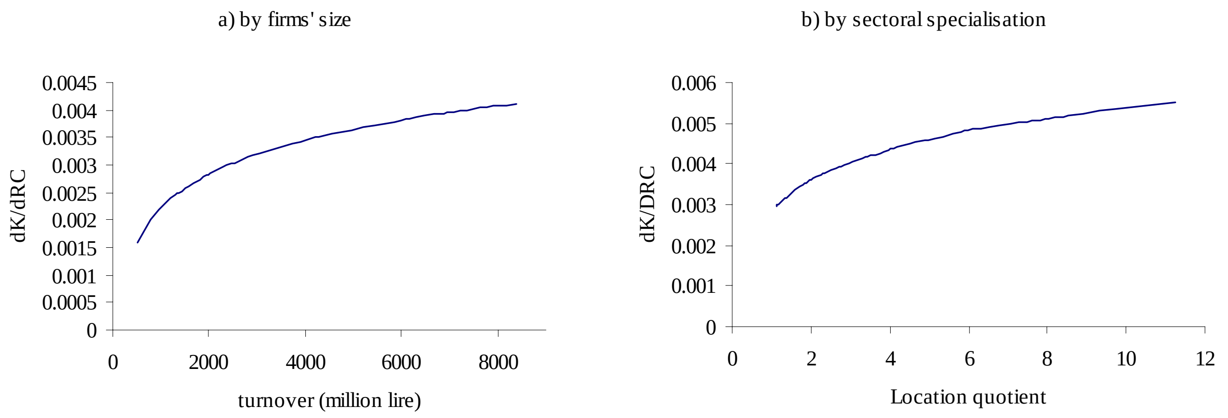


c) Local Districts

Last, but not least, a different picture emerges from the analysis of local district areas. As already explained, in this model it is more interesting to look at the behaviour of firms for what concerns relational capital from one side, and external knowledge acquisition, via strategic alliances with external firms from the other. As already mentioned, the proxy for external networking turned out to be statistically insignificant and unble to explain any of the variance of the product innovation variable. We were therefore unable to test the hypothesis on the importance of external networking as a channel for knowledge acquisition.

The results are presented in Figure 5. Relational capital shows it strongest effects on innovation in large firms. Contrary to the case of non-urban areas, also small firms get a positive advantage on the innovation activity by relational capital; however, this advantage increases with firms size, probably due to the greater capacity of large firms to control local networks and to get adavantage from them. Interestingly enough, the effects of relational capital on innovation decrease while the sectoral specialisation of firms increases. Relational capital thus manifests decreasing returns to scale when specialisation increases, as suggested by most of the literature on innovative SMEs areas (Fig. 5b).

Figure 5. The Effects of Relational Capital on Innovation Activity of Firms In Local Districts



5.2. A Summary Picture

A summary picture of the results achieved is presented in Table 8, which leads to some interesting messages. The empirical results show a high sensitivity to the spatial characteristics of the area analysed, as well as to the sectoral and firms' dimension. The major results are twofold.

Firstly, relational capital has a major impact on the innovation activity of firms in:

- urban production milieux, i.e. in small firms operating in specialised sectors of urban areas;
- specialised non-urban areas organised around the presense of a large firm;
- local districts.

On their turn, scientific knowledge spillovers have a major impact on the innovation activity of firms in:

- despecialised SMEs areas;
- diversified urban areas.

Table 8. A Summary Picture of the Results

Sectoral Characteristics / *Spatial Characteristics*	*Specialised Sectors*	*Diversified Sectors*
Urban Areas	Relational Capital Appreciated by Small Firms in Specialised Sectors (Urban Production Milieux)	Scientific Knowledge Spillovers Appreciated by Large Firms (Typical Dynamic Urbanisation Economies)
Non-urban Areas	Relational Capital Appreciated by Specialised non-urban Areas organised around a Large Firm	Scientific Knowledge Spillovers Appreciated by SMEs
Local Districts	Relational Capital Appreciated by all Firms	

These results lead immediately to the following consideration. It is difficult to argue that "since innovation becomes increasingly based on scientific and technological knowledge combined with creativity, only cities, and especially large cities, where these new resources are disproportionately concentrated, will be able to compete successfully in the global economy". As our results suggest, also non-urban areas are characterised by efficient channels for knowledge acquisition in order to compete at the global level, on the basis of specialised, and technologically and scientifically advanced, knowledge.

6. Conclusions

The findings in this research note have broadened the empirical evidence for the existence of spatial externalities in innovation activities of firms. This extension is threefold. First, relative to the Gremi theory and qualitative analyses developed during the nineties, the research as strengthened the role of relational capital in innovation activity and quantitative results have proved the importance of this role. Secondly, the results have stressed the importance of scientific knowledge spillovers, as suggested by a large and growing body of literature (Acs et al., 1992; Audretch et al., 1999), despite the fact that a different methodology has been applied, based on the estimate of a knowledge production function at the firms' level, rather than at the industry or spatial level. Thirdly, it has emphasised the strategic importance of firms' size spatial and sectoral characteristics in understanding the mechanisms behind knowledge externalities (Anselin et al., 2000).

According to the results, one can easily argue that in local areas mechanisms for acquiring knowledge exist and are important for the innovative capacity of firms; moreover, complementary channels of knowledge acquisition exist in cities, which are appreciated by small firms operating in specialised sectors, and which are similar to the ones which apply at the local district level. The mechanisms of local cooperation, synergy and socialised production of knowledge, labelled relational capital, thus represents the strategic knowledge acquisition channel for non-urban areas to compete in a regime of globalisation. It is of course still true that scientific knwoledge spillovers are another channel for knowledge acquisition, and are particularly appreciated in despecialised environments.

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Appendix. Results of the Factor Analysis

a) Locational Factors useful for Firms' Innovation Activity

Factors and items	Factor coefficients	Variance explained by each factor	Labels
Factor 1		*43.9*	*Infrastructure and environmental externalities*
- Proximity to a good road system	0.86		
- Proximity to a good railways system	0.70		
- Proximity to firms of the same sector	0.71		
Factor 2		*25.3*	*Knowledge spillovers*
- Proximity to public and private research centres	0.99		

Total variance explained: 78.2%
All variables assume 0-1 values (1=yes; 0=no)

b) Local labour market and labour force training

Factors and items	Factor coefficients	Variance explained by each factor	Labels
Factor 1		*17.1*	*Knowledge acquired from other local firms via the local labour market*
- high share of employees (50%) previously working in other local firms	0.71		
- employees trained in other local firms	0.73		
Factor 2		*16.7*	*Knowledge acquired from external firms via the labour market*
- high share of employees (50%) previously working in external firms	0.66		
- employees trained in external firms	0.63		
- employees trained within the firm	-0.59		
Factor 3			*Recruitment from outside the area*
- high share of employees (>50%) recruited from outside	0.88		
Factor 4		*14.3*	*Recruitment within the area and satisfaction for the local labour market quality*
- Satisfaction about the quality of the local labour market	0.85		
- high share of employees (>50%) recruited within the area	0.46		

Total variance explained: 64.8%
All variables assume 0-1 values (1= yes; 0=no)

c) Relationships with other firms (which are not suppliers and customers)

Factors	Factor coefficients	Variance explained by each factor	Labels
Factor 1		*23.5*	*External networking*
- high share of cooperative firms (>50%) located outside the area	0.79		
- cooperation leading to a control on strategic complementary assets for the firm	0.55		
- high share of cooperative firms (>50%) located within the area	-0.55		
Factor 2		*20.9*	*Cooperation for technological knowledge exchange*
- satisfaction of the role of other firms in the innovation activity of the firm	0.68		
- cooperation leading to exchange of technological knowledge	0.81		
Factor 3		*17.6*	*Cooperation for exchange of experiences on different production processes*
- high share of cooperative firms (>50%) located within the province	-0.77		
- cooperation leading to exchange of different production processes	0.49		

Total variance explained: 62.9%
All variables assume 0-1 values (1= yes; 0=no)